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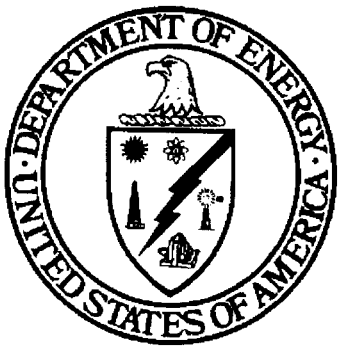
WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1999

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

JULY 2000 **REV. 0**



U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MORRISON KNUDSEN CORPORATION MK-FERGUSON GROUP Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	
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PLAN TITLE: Weldon Spring Site Environmental Report for Calendar Year 1999	

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DOE/OR/21548-845

Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY

Weldon Spring Site Environmental Report for Calendar Year 1999

Revision 0

July 2000

Prepared by

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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 1999* has been prepared to provide information about the public safety and environmental protection programs conducted by the Weldon Spring Site Remedial Action Project (WSSRAP). The Weldon Spring site is located in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. The chemical plant, raffinate pits, and quarry are located on Missouri State Route 94, southwest of U.S. Route 40/61.

The objectives of the *Site Environmental Report* are to present a summary of data from the environmental monitoring program, to identify trends and characterize environmental conditions at the site, and to confirm compliance with environmental and health protection standards and requirements. The report also presents the status of remedial activities and the results of monitoring these activities to assess their impacts on the public and environment.

This report includes monitoring data from routine radiological and nonradiological sampling activities and summarizes special environmental study findings. These data include estimates of dose to the public from the Weldon Spring site, estimates of effluent releases, and trends in groundwater contaminant levels. Additionally, applicable compliance requirements, quality assurance programs, and special studies conducted in 1999 to support environmental protection programs are discussed.

Dose estimates presented in this report are based on hypothetical exposure scenarios for public use of areas near the site. In addition, release estimates have been calculated on the basis of 1999 National Pollutant Discharge Elimination System (NPDES) and air monitoring data. Effluent discharges from the site under routine NPDES and National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring were below permitted levels for radionuclides.

MONITORING OVERVIEW

WSSRAP environmental management programs are designed to ensure that releases from the site are at levels demonstrably and consistently "as low as reasonably achievable" (ALARA). The ALARA principle drives the work activities related to site remediation and contaminant cleanup programs under U.S. Environmental Protection Agency (EPA) enforcement of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA).

Effluent and environmental monitoring programs provide early detection of contaminants, assessment of potential impacts to the environment, and data needed to implement the ALARA strategy. Routine monitoring also demonstrates compliance with applicable State and Federal permits and regulations.

REGULATORY COMPLIANCE

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the CERCLA. Under the CERCLA, the WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations include the *Resource Conservation and Recovery Act* (RCRA), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *Toxic Substances Control Act* (TSCA), the *National Historic Preservation Act* (NHPA) and, because the U.S. Department of Energy (DOE) is the lead agency for the site, the incorporation of the *National Environmental Policy Act* (NEPA) values into CERCLA documents as outlined in the Secretarial Policy statement on NEPA.

The following major tasks were completed at the Weldon Spring site during 1999:

- The Site Water Treatment Plant treated 185 million liters (48.9 million gallons) of contaminated water, including 42 million liters (11 million gallons) of high selenium wastewater. The treated effluent consistently met NPDES permit requirements.

- A brine treatment system was constructed and used to treat over 4,100 tons of high selenium brine, in accordance with RCRA regulations.

- Various chemical and radiological wastes were stabilized, treated and/or shipped in accordance with RCRA and TSCA regulations.

- A large portion of the chemical plant area, including Raffinate Pits 3 and 4, the Ash Pond area, and the northern and southern sections of the TSA were successfully remediated in accordance with CERCLA requirements.

- Raffinate Pits 1 and 2 were dewatered and excavated down to firm clay, with final remediation activities to be conducted during 2000.

- The Chemical Stabilization/Solidification facility was dismantled and disposed.

- Bedding and riprap erosion control was installed on the south, west, and east side slopes of the permanent disposal cell. One foot of clean soil radon barrier was installed over the southern two-thirds of the cell.

- The quarry sump was dewatered and the Quarry Water Treatment Plant treated 21.2 million liters (5.6 million gallons) of wastewater. The treated effluent met NPDES permit requirements.

- The *Remedial Design/Remedial Action Work Plant for the Quarry Residuals Operable Unit* was developed during 1999 and finalized in January 2000.

- The final *Supplemental Feasibility Study for Remedial Action for the Groundwater Operable Unit* was issued in August 1999.

MONITORING SUMMARY

Environmental monitoring data showed that dose estimates were below the DOE guidelines of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. NESHAPs air monitoring results for radioactive air particulates showed that dose estimates were all well below the NESHAPs standard of 10 mrem (0.1 mSv) per year. Radon monitoring at perimeter and critical receptor locations showed no Rn-220 or Rn-222 concentrations above background levels.

Release estimates for total uranium in water (which include storm water and water from the treatment plants) decreased significantly from the 1998 release estimate of 23.8 kg/yr (52.4 lb/yr) to 9.56 kg/yr (21.08 lb/yr) in 1999. The annual release of total uranium for 1999 is a 98% reduction from the 1987 annual estimate. Effluent releases were below the DOE derived concentration guide level of 600 pCi/l. Data from groundwater and surface water monitoring indicated no measurable impact on drinking water sources from Weldon Spring site contaminants.

Dose Estimates

Radiation dose estimates are discussed in Section 5. The maximum total effective dose equivalent to a hypothetical individual employed full-time at the Missouri Highway and Transportation Department (MHTD) facility during 1999 was 2.63 mrem (0.026 mSv). This scenario assumed an individual working at the facility 2,000 hours/year. The total effective dose equivalent to a maximally exposed individual at the vicinity properties from consumption of water was 0.31 mrem (0.003 mSv). This scenario assumed an individual walking past Burgermeister Spring once per week and drinking one cup (0.237 l) of spring water each visit. These estimates are well below the DOE guideline of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. By comparison, the annual total effective dose equivalent in the United States due to naturally occurring sources of radioactivity is approximately 300 mrem (3 mSv).

The collective population effective dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area and employees of the Missouri Highway and Transportation Department (MHTD) facility and WSSRAP administration building was 0.18 person-rem (0.002 person-Sv). The Busch Conservation Area estimate was based on an affected population of 200,000 persons assumed to have potential for exposure through ingestion

of fish, water, sediments. The MHTD estimate was based on a staff of nine full-time employees exposed to above-background levels of radioactive airborne particulates and gamma radiation. The WSSRAP administration building estimate was based on a staff of 160 employees being exposed to elevated concentrations of radioactive airborne particulates.

Air Monitoring

As discussed in Section 4, airborne releases from the Weldon Spring Chemical Plant area include Rn-220, Rn-222 gas, their progeny, and radioactive airborne particulates. Radioactive airborne particulates are assumed to include Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium.

During 1999, no critical receptor or perimeter monitoring station recorded Rn-220 or Rn-222 concentrations above background levels. Statistical analysis of integrated radon track etch data indicates that the concentration at one interior station near the raffinate pits was greater than background levels. Statistical analysis of modified track etch detector data indicates that one station at the raffinate pits and two stations at the disposal cell exceeded background levels of Rn-220. All track etch results were below the derived concentration guide (DCG) for Rn-222 and Rn-220 of 3 pCi/l (0.11 Bq/l).

The results of NESHAPs monitoring for radioactive particulate which are discussed in Section 6, indicated that all doses to the public at critical receptor locations were less than the NESHAPs standard of 10 mrem (0.1 mSv) per year. Critical receptor locations included the Missouri Highway Maintenance Facility, Busch Memorial Conservation Area, Francis Howell High School and Annex, the WSSRAP administration building, the nearest quarry residence, and the Department of the Army Weldon Spring Training Area. Statistical analysis of NESHAPs monitoring results indicated that at the 95% confidence level all stations were indistinguishable from background.

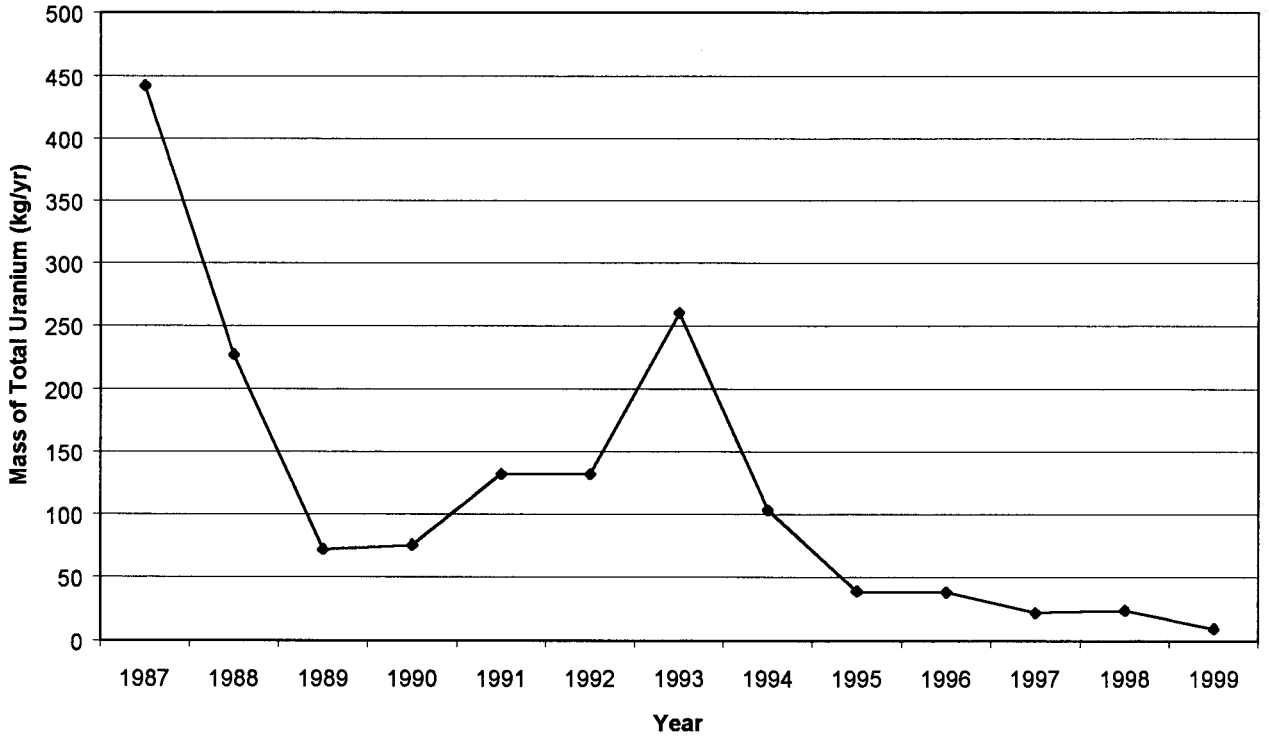
All environmental asbestos monitoring results were below the EPA limit of 0.01 fiber/ml. Asbestos monitoring was conducted in 1999 at Francis Howell High School and five site perimeter stations.

NPDES Monitoring

In 1999, surface water runoff at the chemical plant transported uranium from the site through six major discharge routes that are identified in Section 7 of this report. The total mass of uranium migrating off-site in storm water and treated effluent was 9.56 kg/yr (21.08 lb/yr). Based on natural uranium activity ratios, this is equivalent to an activity of 0.0065 Ci/yr (2.41E8 Bq/yr). The total mass of uranium was less than half the 1998 mass of 23.8 kg/yr (52.4 lb/yr). The graph below, also presented as Figure 11-5 in Section 11, shows that the total

mass of uranium migrating off site in storm water and treated effluent has decreased substantially since remedial activities began, and is now approaching background.

Total Annual Uranium Discharged at NPDES Outfalls



Annual average uranium concentrations at the NPDES outfalls were all well below the derived concentration guideline of 600 pCi/l. With respect to 1998 levels, average uranium concentrations increased at Outfalls NP-0005, NP-0007, and NP-1001 and decreased at Outfalls NP-0002, NP-0003, NP-0004, and NP-0010. The increases and decreases were generally slight. Historical uranium trends for the three major NPDES outfalls (i.e., NP-0002, NP-0003, and NP-0005) are discussed in Section 11.

Radiological parameters at the outfalls were in compliance with NPDES permit requirements during 1999. Other parameters were also in compliance except on three occasions: one site water treatment plant (Outfall NP-0007) sample exceeded the permit limit for selenium, and two storm water samples collected at NP-0002 and NP-0005 exceeded the permit limit for settleable solids. Details of these exceedances are presented in Section 2.5.

Missouri River sediment was monitored during 1999 in support of site and quarry water treatment plant operations. Sediment samples were taken from the river both upstream and downstream of the treatment plant discharges and analyzed for uranium. The sample results

indicate that the treatment plant discharges have caused no increase in uranium concentrations in river sediment.

Surface Water

Surface water monitoring in 1999 indicated that contaminant concentrations were within historic ranges. Average uranium levels at off-site surface water locations downgradient of the chemical plant were all lower than 1998 levels.

Groundwater

The groundwater monitoring program included extensive monitoring for radiological and chemical compounds, as discussed in Section 8. Radiological results for the St. Charles County well field remained within background levels. No detectable concentrations of the six nitroaromatic compounds of concern were found in groundwater monitoring wells south of the Femme Osage Slough, including the well field, which is near the quarry.

Environmental groundwater monitoring indicates that nitroaromatic and uranium contamination is still present in the bedrock of the quarry rim and in the alluvial materials and bedrock north of the Femme Osage Slough. Trend analysis indicates a downward or stationary trend in both contaminants at all but one location.

The contamination plume underlying the chemical plant area continued to be monitored during 1999. With the exception of increasing nitroaromatic compounds in the vicinity of Frog Pond, contaminant levels generally remained within historic ranges. Nitrate and uranium continue to be present, especially in the raffinate pits area. Trichloroethene exhibited downward or stationary trends at the wells in which it was detected.

Monitoring data from wells placed around the waste management units, including the permanent disposal cell, showed no exceedances of baseline for radiological parameters. Several wells exceeded established baseline levels for nonradiological contaminants, but these data are likely due to natural variations in the existing contamination plume underlying the site.

Biological

The U.S. Department of Energy (DOE) has completed its third and final year of wetland monitoring at the DOE-funded mitigation wetland complex located on the August A. Busch Conservation area. As discussed in Section 9, no fish monitoring was conducted in 1999 because total uranium monitoring results for sunfish collected from Busch Lakes 33 and 35 during 1998 were within background ranges.

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Weldon Spring Site Remedial Action Project

Weldon Spring Site Environmental Report for Calendar Year 1999

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ABSTRACT

This *Site Environmental Report for Calendar Year 1999* describes the environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). The objectives of these programs are to assess actual or potential exposure to contaminant effluents from the project area by providing public use scenarios and dose estimates, to demonstrate compliance with Federal and State permitted levels and regulations, and to summarize trends and/or changes in contaminant concentrations identified through environmental monitoring.

In 1999, the maximum total effective dose equivalent (TEDE) to a hypothetical individual who was employed full-time at the nearby Missouri Highway and Transportation (MHTD) facility was 2.63 mrem (0.0263 mSv). The maximum TEDE to a hypothetical individual who frequents the Weldon Spring Vicinity Properties was 0.31 mrem (0.003 mSv). These estimates are below the U.S. Department of Energy requirements of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways.

The combined collective population dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area (200,000 individuals) and employees of the MHTD facility (nine individuals) and WSSRAP administration building (160 individuals) was 0.18 person-rem (0.0018 person-Sv).

Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutant (NESHAPs) program indicated that the maximally exposed individual, who resides continuously near the Busch Memorial Conservation Area, received an effective dose equivalent of 0.33 mrem (0.003 mSv) during 1999. This is well below the U.S. Environmental Protection Agency (EPA) standard of 10 mrem (0.1 mSv) per year.

Comprehensive monitoring at the WSSRAP has indicated that emissions of radiological compounds in airborne and surface discharges from the Weldon Spring site consisted primarily of Rn-220 gas, Rn-222 gas, isotopes of thorium and radium, and natural uranium. During 1999, no critical receptor or perimeter monitoring station recorded Rn-220 or Rn-222 concentrations above background levels. In addition, there was no measurable impact to any drinking water source from radionuclides.

Concentration limits are set for water pollutants in the NPDES permits. Parameters were in compliance with the permit limits except on three occasions. The selenium limit was exceeded at the site water treatment plant outfall, and the settleable solids limit was exceeded at two storm water outfalls. The total mass of uranium migrating off site in storm water and treated effluent during 1999 was 9.56 kg (21.08 lb).

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1. INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the DOE Office of Environmental Management. This *Weldon Spring Site Environmental Report for Calendar Year 1999* summarizes the environmental monitoring results obtained in 1999 and presents the status of Federal and State compliance activities.

DOE requirements for environmental monitoring and protection of the public, the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program;* DOE Order 5400.5, *Radiation Protection of the Public and Environment;* and the implementation guide for DOE Order 5400.5, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*.

In 1999, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *Clean Air Act* (CAA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the WSSRAP has been designed to protect the public and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Weldon Spring Site Environmental Report for Calendar Year 1999* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 1999 environmental monitoring program.
- Providing information regarding ongoing remedial actions.
- Reporting compliance with Federal, State, and local requirements and DOE standards.
- Providing dose estimates for public exposure to radiological compounds due to remedial activities at the WSSRAP.

- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, maintain surveillance monitoring requirements, and demonstrate the effectiveness of the remediation.

1.1 Site Description

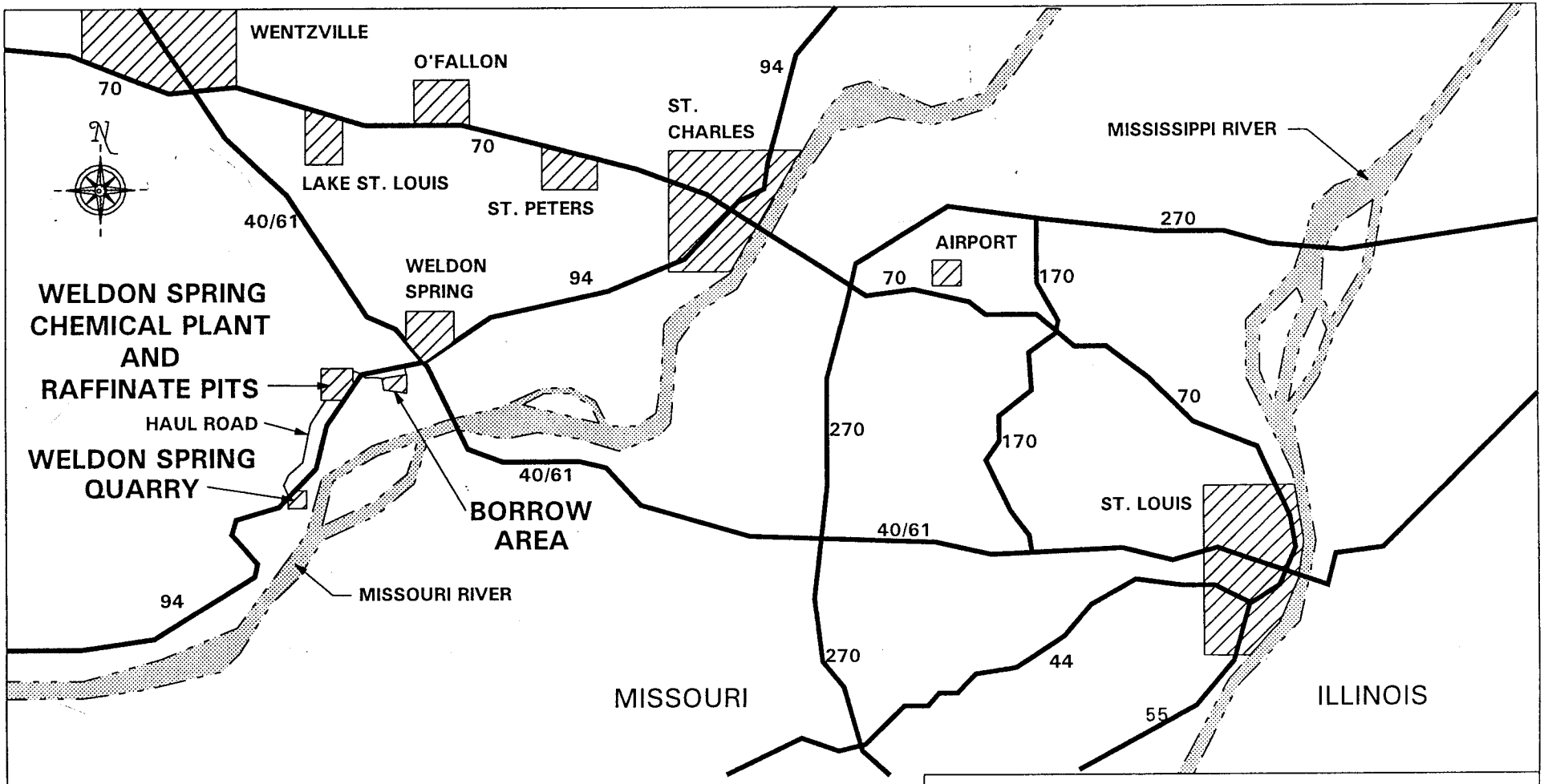
The Weldon Spring site is located in southern St. Charles County, Missouri approximately 48 km (30 mi) west of St. Louis, as shown in Figure 1-1. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. Access to both the site and quarry is restricted by locked chain link fences with on-site security.

The Weldon Spring Chemical Plant is a 91 ha (226 acre) area that operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants have been found in the soil in many areas around the site. The raffinate pits are located on the chemical plant site and consist of four settling basins that cover approximately 10.5 ha (26 acres), as shown in Figure 1-2. These pits were characterized as being contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals (Ref. 2). The two largest pits were remediated and backfilled in 1999, and the remaining two pits will be remediated in 2000.

The Weldon Spring Quarry is a former 3.6 ha (9 acre) limestone quarry located south-southwest of the chemical plant area (Figure 1-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump. The amount of water in the sump varies in response to quarry water treatment plant operations and precipitation. The quarry bulk waste removal operation was completed in 1995. The bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos (Ref. 1).

1.2 Site History

From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Memorial Conservation Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Army training area.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

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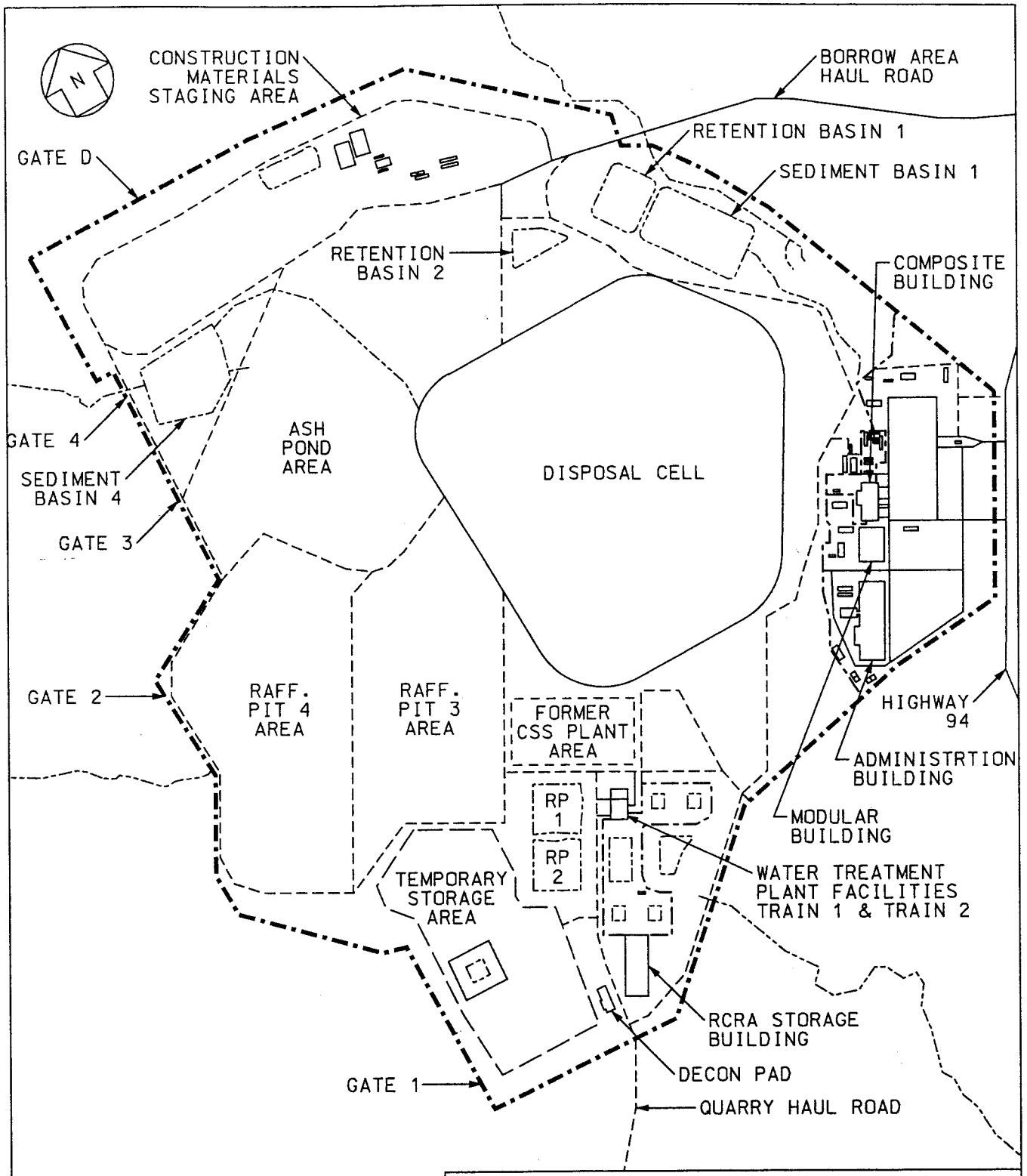

WELDON SPRING CHEMICAL PLANT AND RAFFINATE PIT AREAS

FIGURE 1-2

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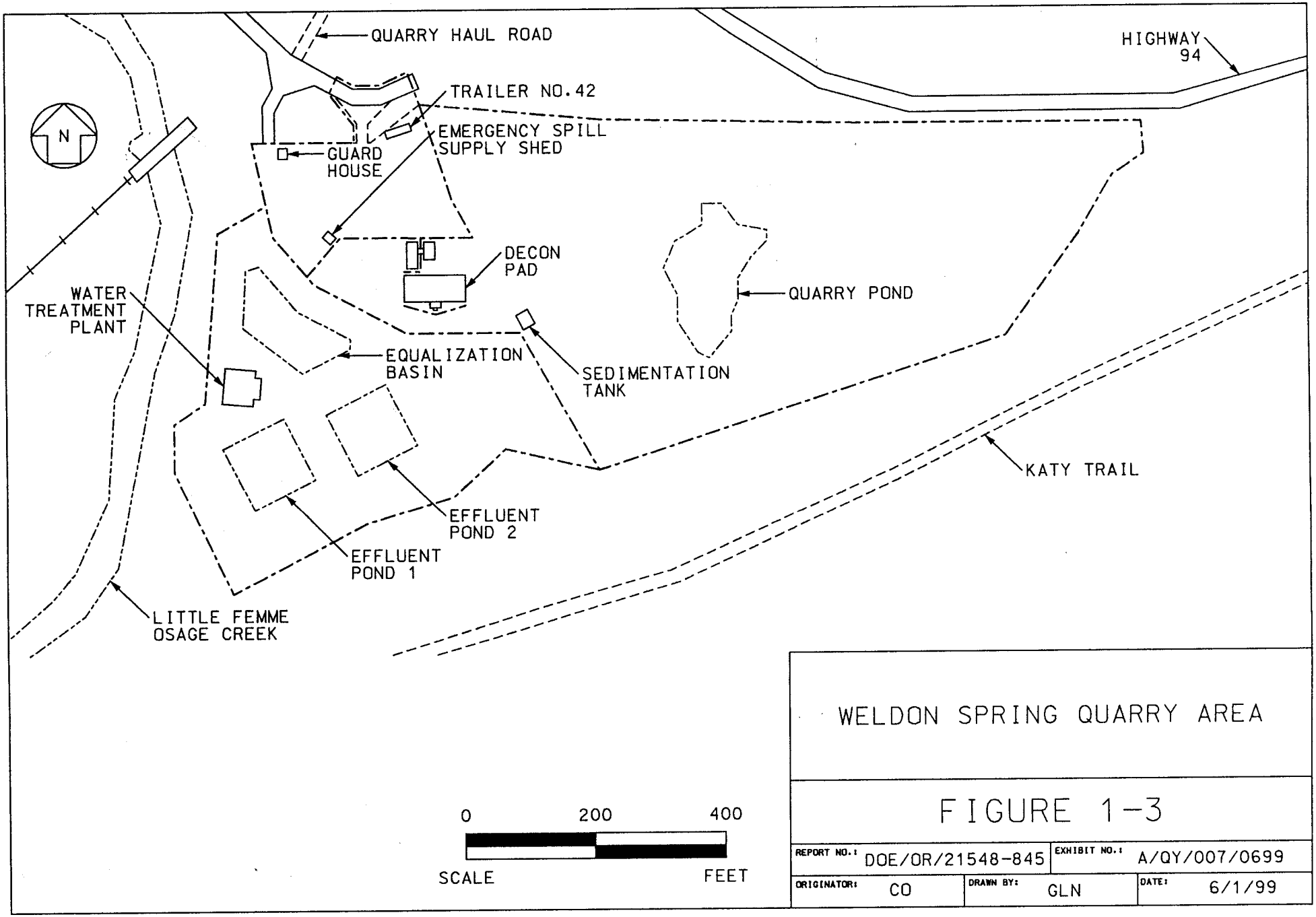

WELDON SPRING QUARRY AREA

FIGURE 1-3

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Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former ordnance works property were transferred in May 1955 to the AEC for construction of the Weldon Spring Uranium Feed Materials Plant (WSUFMP), now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by the Atlas Powder Company and the Army prior to WSUFMP construction. From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed. Wastes generated during these operations were stored in the four raffinate pits.

In 1958, the AEC acquired title to the Weldon Spring Quarry from the Army. The Army had used it since 1942 for burning wastes from the manufacture of TNT and DNT and disposal of TNT-contaminated rubble during the operation of the ordnance works. Prior to 1942, the quarry was mined for limestone aggregate used in the construction of the ordnance works. The AEC used the quarry from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Material disposed of in the quarry during this time consisted of building rubble and soils from the demolition of a uranium ore processing facility in St. Louis. These materials were contaminated with uranium and radium. Other radioactive materials in the quarry include drummed wastes, uncontained wastes, and contaminated process equipment.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. However, the defoliant project was canceled in 1969 before any process equipment was installed. The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The Weldon Spring site was placed in caretaker status from 1981 through 1985, when custody was transferred from the Army to the Department of Energy. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

A more detailed presentation of the production, ownership, and waste history of the Weldon Spring site is available in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 1) and the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 2).

1.3 Geology and Hydrogeology

The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 3).

The uppermost bedrock units underlying the Weldon Spring Chemical Plant are the Mississippian Burlington and Keokuk Limestone. Overlying the bedrock are unlithified units consisting of fill, top soil, loess, glacial till and limestone residuum of thicknesses ranging from a few feet to several tens of feet.

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones and the middle aquifer consists of the Ordovician Kimmswick Limestone. The deep aquifer includes formations from the top of the Ordovician St. Peter Sandstone to the base of the Cambrian Potosi Dolomite. Alluvial aquifers of Quaternary age are present near the Missouri and Mississippi Rivers.

The Weldon Spring Quarry is located in low limestone hills near the northern bank of the Missouri River. The mid-Ordovician bedrock of the quarry area includes, in descending order, the Kimmswick Limestone, Decorah Formation, and Plattin Limestone. These formations are predominantly limestone and dolomite. Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (Ref. 4). Massive quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the quarry.

1.4 Surface Water System and Use

The chemical plant and raffinate pits area is located on the Missouri-Mississippi River surface drainage divide, as shown in Figure 1-4. Elevations on the site range from approximately 185 m (608 ft) above mean sea level (msl) near the northern edge of the site to 205 m (673 ft) above msl near the southern edge. The topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Ref. 3). There were two contaminated surface water bodies at the chemical plant area in 1999: Raffinate Pits 1 and 2. All other contaminated ponds and pits were dewatered prior to 1999.

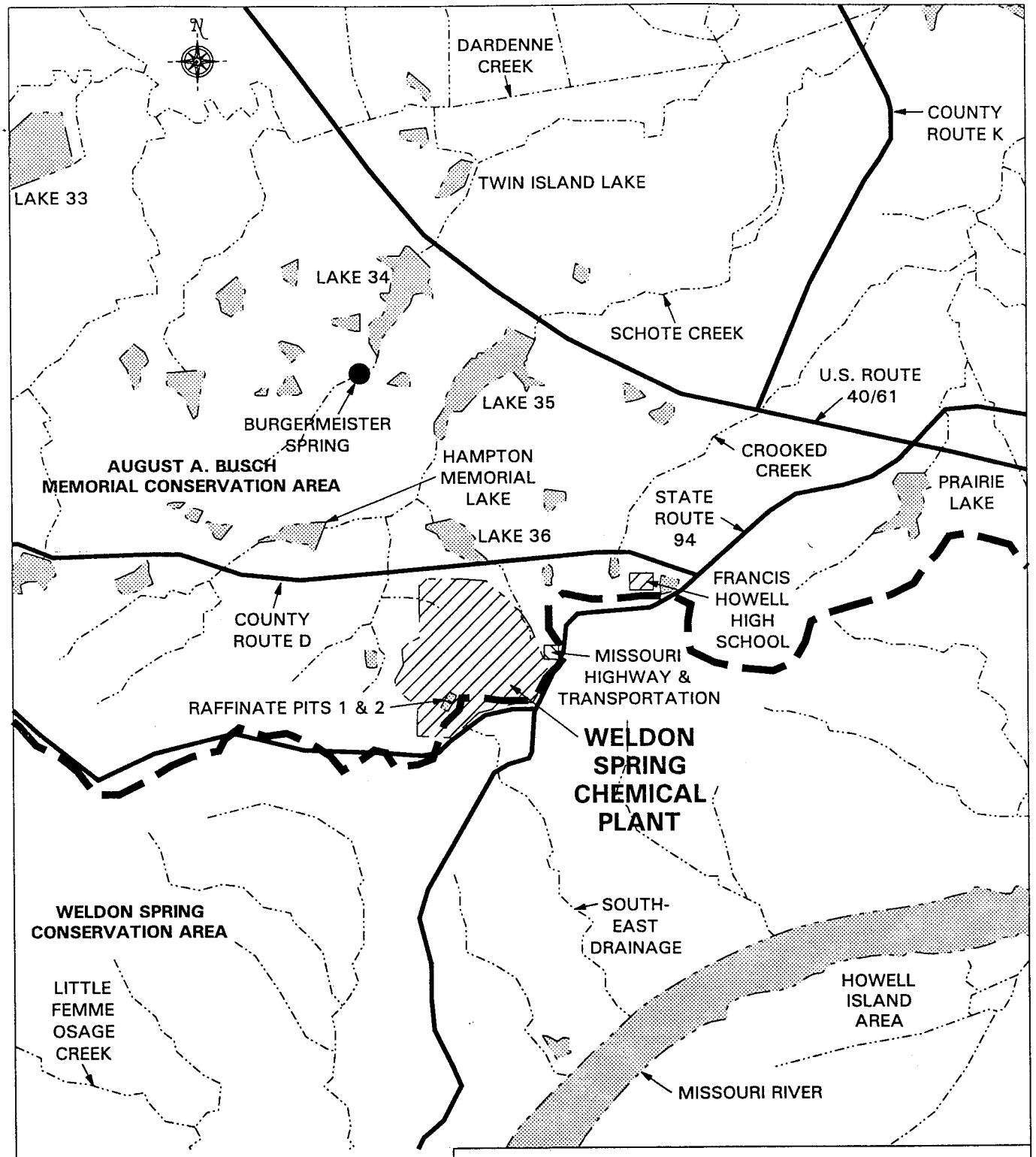
No natural drainage channels traverse the site, although remnants of a channel through the Ash Pond area are present. Drainage from the southeastern portion of the site generally flows southward to a tributary referred to as the Southeast Drainage (5300 Drainageway) that flows to the Missouri River.

In the surrounding areas, man-made lakes in the August A. Busch Memorial Conservation Area are used for public fishing and boating. No swimming is allowed in the conservation area, although some may occur. No surface water is used for irrigation or as a public drinking water supply. The northern and western portions of the chemical plant site drain to tributaries of Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River.

Four sedimentation basins were used to minimize discharge of sediment from the site during remediation efforts in 1999. One basin is downstream of the Ash Pond area and collects Ash Pond runoff water as well as all waters that discharge at Outfall NP-0003. A second basin collects most water from the northeast section of the site and discharges to Outfall NP-0002. The third basin collects water from the site water treatment plant area and discharges to Outfall NP-0005. The fourth is just upstream of NP-0010 and collects runoff from a portion of the CMSA. These basins are discussed in more detail in Section 7.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 km (1 mi) northwest of the Missouri River at approximately River Mile 49. No direct surface water runoff enters or exits the quarry due to the topography of the area. A 0.07 ha (0.2 acre) pond within the quarry proper acts as a sump that accumulates both direct rainfall within the quarry and the groundwater. Past dewatering activities in the quarry suggest that the sump interacts directly with the local groundwater. Bulk waste removal, which included removal of some sediment from the sump area, was completed at the quarry during 1995. The surface area of the sump remains at 0.07 ha (0.2 acres). The quarry pond is not used for any operational or public water supply and is maintained by the DOE within an access-controlled and restricted area.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the quarry, is a 2.4 km (1.5 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University's experimental farms (Ref. 4). The slough receives contaminated groundwater migrating from the quarry, causing increased uranium concentrations in the slough. The slough is used for recreational fishing.



PHYSICAL FEATURES OF WELDON SPRING AREA

FIGURE 1-4

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/078/1193		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/21/00

1.5 Ecology

The Weldon Spring site is surrounded primarily by State Conservation Areas that include the 2,828 ha (6,988 acre) Busch Conservation Area to the north, the 2,977 ha (7,356 acre) Weldon Spring Conservation Area to the east and south, and the Howell Island Conservation Area, an island in the Missouri River which covers 1,031 ha (2,548 acres) (Figure 1-4). The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing comprises a relatively large portion of the recreational use. Seventeen percent of the area is open fields that are leased to sharecroppers for agricultural production. In these areas, a percentage of the crop is left for wildlife use. The main agricultural products are corn, soybeans, milo, winter wheat, and legumes (Ref. 5). The Busch and Weldon Spring Conservation Areas are open year-round, and the number of annual visits to both areas totals about 1,200,000.

The quarry is surrounded by the Weldon Spring Conservation Area, which consists primarily of forest with some old field habitat. Prior to bulk waste removal, the quarry floor consisted of old-field habitat containing a variety of grasses, herbs, and scattered wooded areas. Since bulk waste removal began this habitat has been disturbed. The rim and upper portions of the quarry still consist primarily of slope and upland forest including cottonwood, sycamore, and oak (Ref. 4).

1.6 Climate

The climate in the Weldon Spring area is continental with warm to hot summers and moderately cold winters. Alternating warm/cold, wet/dry air masses converging and passing through the area cause frequent changes in the weather. Although winters are generally cold and summers hot, prolonged periods of very cold or very warm to hot weather are unusual. Occasional mild periods with temperatures above freezing occur almost every winter and cool weather interrupts periods of heat and humidity in the summer (Ref. 6).

The National Oceanic and Atmospheric Administration has published the following information based on analysis of long-term meteorological records for the St. Louis area. Taking into account the past 30 years of data, the average annual temperature is 13.4 C (56.1°F). The average daily maximum and minimum temperatures are 18.6°C (65.4 F) and 8.2°C (46.7°F), respectively. Maximum temperatures above 32.2°C (90 F) occur 35-40 days per year. Minimum daily temperatures below 0°C (32 F) occur about 100 days of the year. Temperatures below -18°C (0°F) are infrequent, occurring only 2-3 days per year. Mean annual precipitation in the area is approximately 95.0 cm (37.5 in.).

Wind data recorded on site since 1994 indicate that prevailing winds are from the south and southwest. The average recorded wind speed is 2.9 m/s (6.6 mph) from the south-southwest.

The meteorological station located at the chemical plant provides data to support site environmental monitoring programs. The station provides data on wind speed, wind direction, ambient air temperature, relative humidity, solar radiation, barometric pressure, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which help determine possible impacts of airborne contaminant releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

On-site meteorological data recovery exceeded 99% in 1999. The quality of all data was assured by a qualified off-site meteorologist. Averages and totals are presented in Table 1-1. Precipitation was about 10% lower than normal for the St. Louis area; however, average recorded temperature, wind speed, and wind direction were all within historical ranges.

Table 1-1 Monthly Meteorological Monitoring Results for 1999

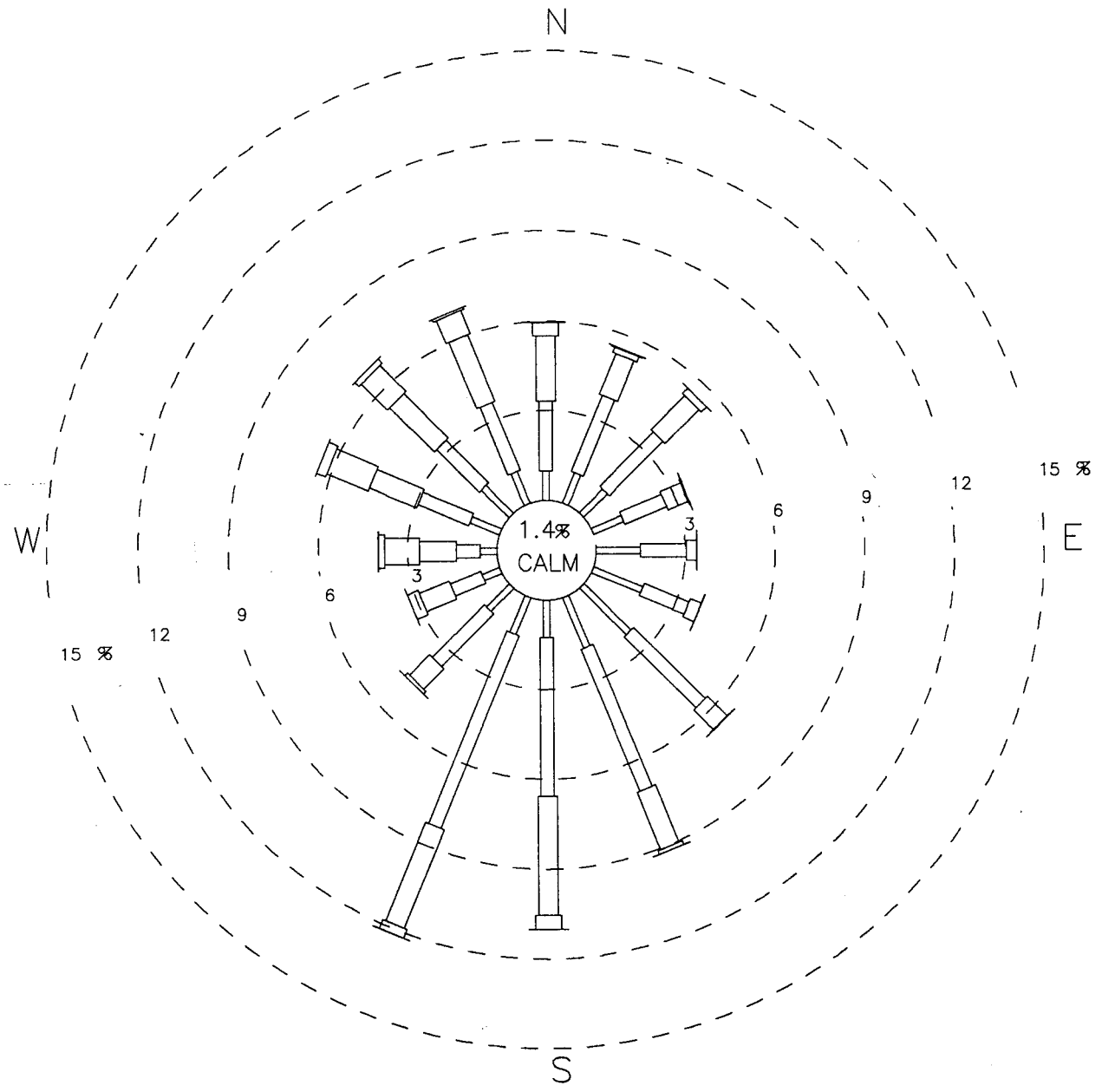
MONTH	TOTAL PRECIP (CM)	AVERAGE TEMP (DEGREES C)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	9.4	-0.7	3.3	NE – 9.0%
February	8.7	5.6	3.6	S – 13.4%
March	6.7	5.6	3.3	NNW – 12.4%
April	8.7	14.4	3.6	SSW – 9.7%
May	6.1	18.6	3.1	SSE – 27.6%
June	13.2	22.4	2.1	SSE – 15%, S-14.9%
July	9.4	26.9	2.1	SSW – 28.1%
August	6.7	23.7	2.1	NE – 10.6%
September	2.9	20.0	2.4	SSW – 16.1%
October	4.7	14.4	2.6	SSW – 16.1%
November	2.4	11.7	2.9	SSW – 21.1%
December	7.6	3.2	3.2	S – 14.8%
Annual Average/Total	86.6	13.8	2.9	SSW (12.2%)

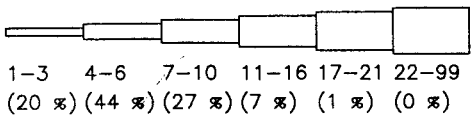
An annual wind rose is presented as Figure 1-5. Figures 1-6 through 1-9 are wind roses for each quarter of 1999.

1.7 Land Use and Demography

The population of St. Charles County in 1999 was 277,200. Twenty percent of the population lives in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles County increased by 30% from 1990 to 1999. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about

Wind Direction and Speed Distribution





WIND SPEED SCALE (MPH)

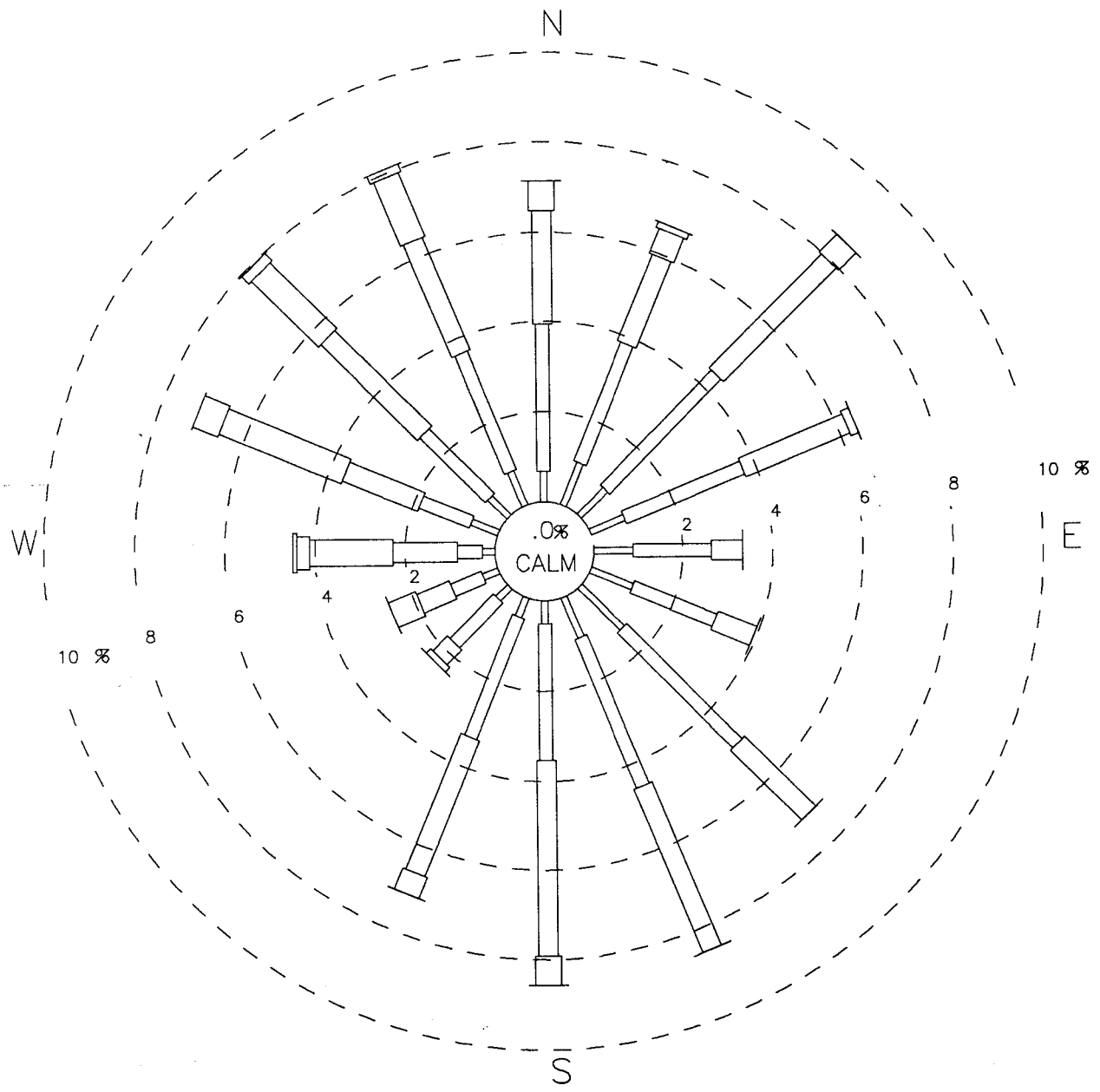
NOTE: WIND DIRECTION IS THE DIRECTION THE WIND IS BLOWING FROM

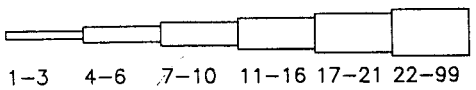
1999 WINDROSE
WELDON SPRING SITE
METEORLOGICAL STATION

FIGURE 1-5

REPORT NO.:	DOE\OR\21548-845	EXHIBIT NO.:	A/PI/018/0498		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/25/00

Wind Direction and Speed Distribution





1–3 (12 %) 4–6 (38 %) 7–10 (36 %) 11–16 (12 %) 17–21 (1 %) 22–99 (0 %)

WIND SPEED SCALE (MPH)

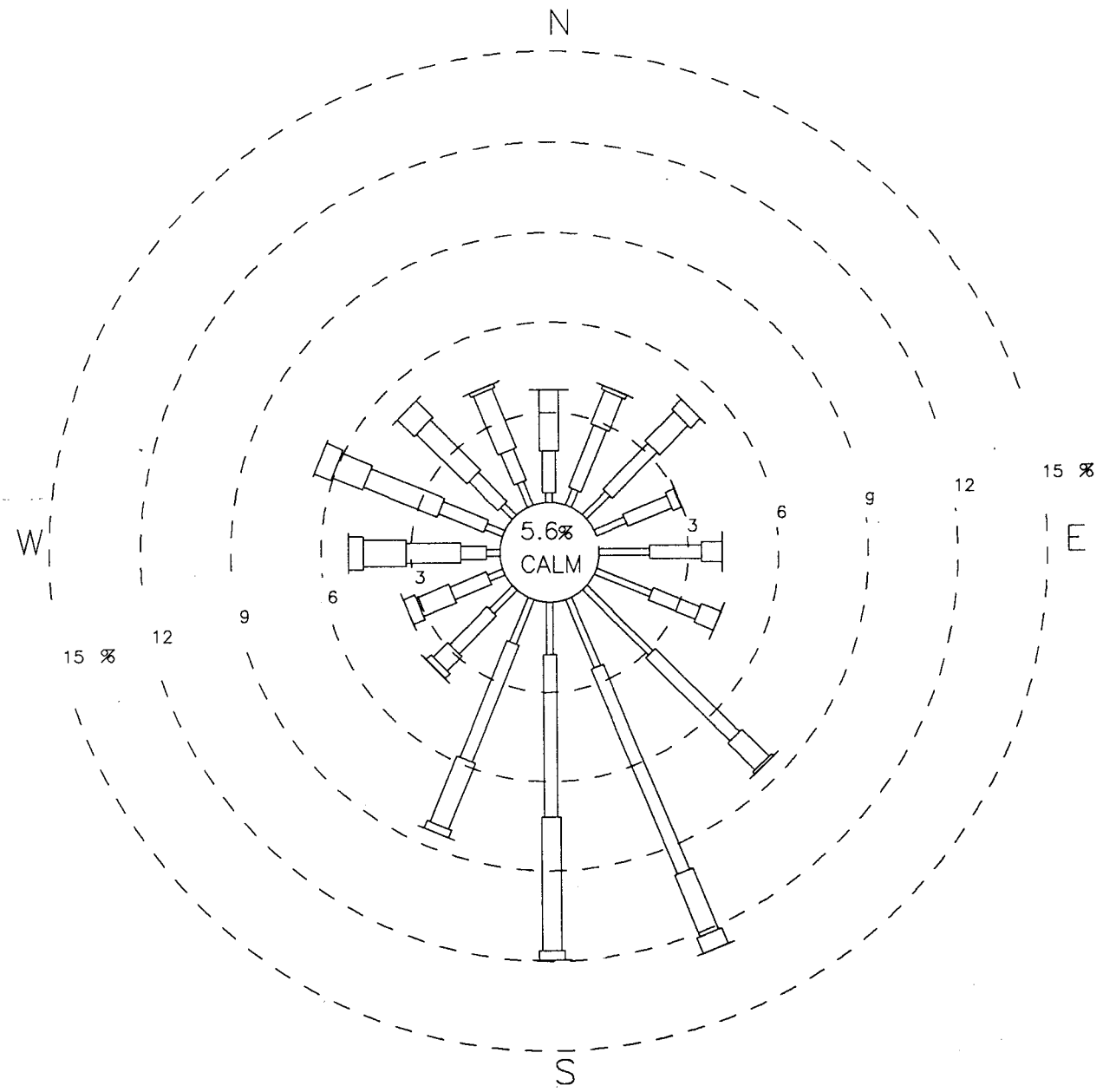
NOTE: WIND DIRECTION IS THE DIRECTION THE WIND IS BLOWING FROM

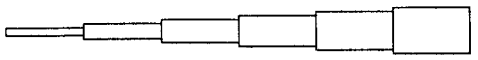
1st QUARTER 1999
WINDROSE FOR THE
WELDON SPRING SITE
METEORLOGICAL STATION

FIGURE 1-6

REPORT NO.:	DOE\OR\21548-845	EXHIBIT NO.:	A/PI/003/0599		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/25/00

Wind Direction and Speed Distribution





1–3 (20 %) 4–6 (40 %) 7–10 (27 %) 11–16 (6 %) 17–21 (1 %) 22–99 (0 %)

WIND SPEED SCALE (MPH)

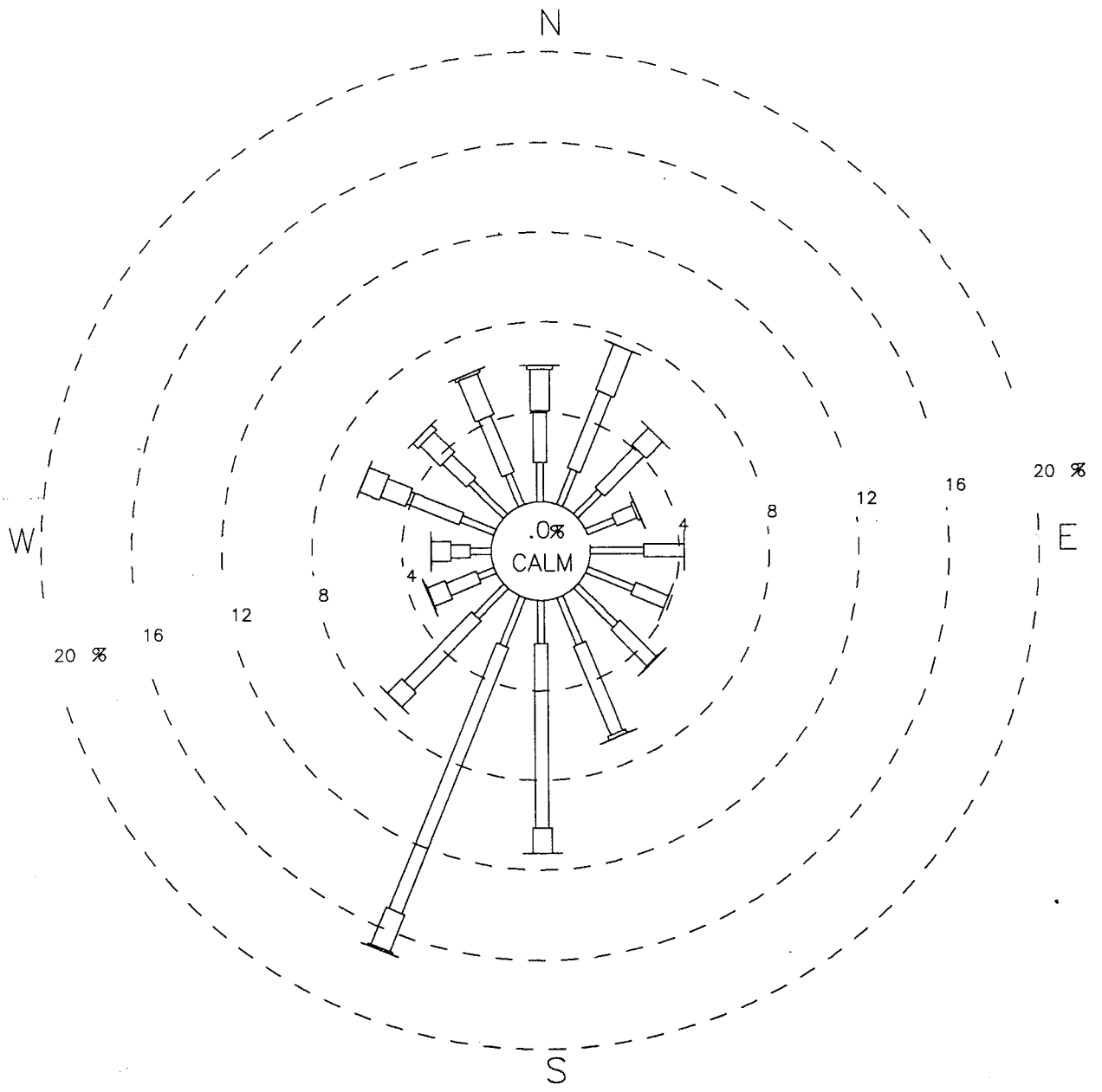
NOTE: WIND DIRECTION IS THE DIRECTION THE WIND IS BLOWING FROM

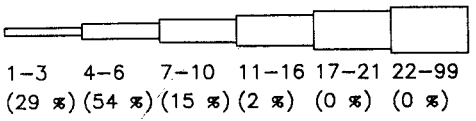
2nd QUARTER 1999 WINDROSE FOR THE WELDON SPRING SITE METEORLOGICAL STATION

FIGURE 1-7

REPORT NO.:	DOE\OR\21548-845	EXHIBIT NO.:	A/PI/004/0599		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/25/00

Wind Direction and Speed Distribution





WIND SPEED SCALE (MPH)

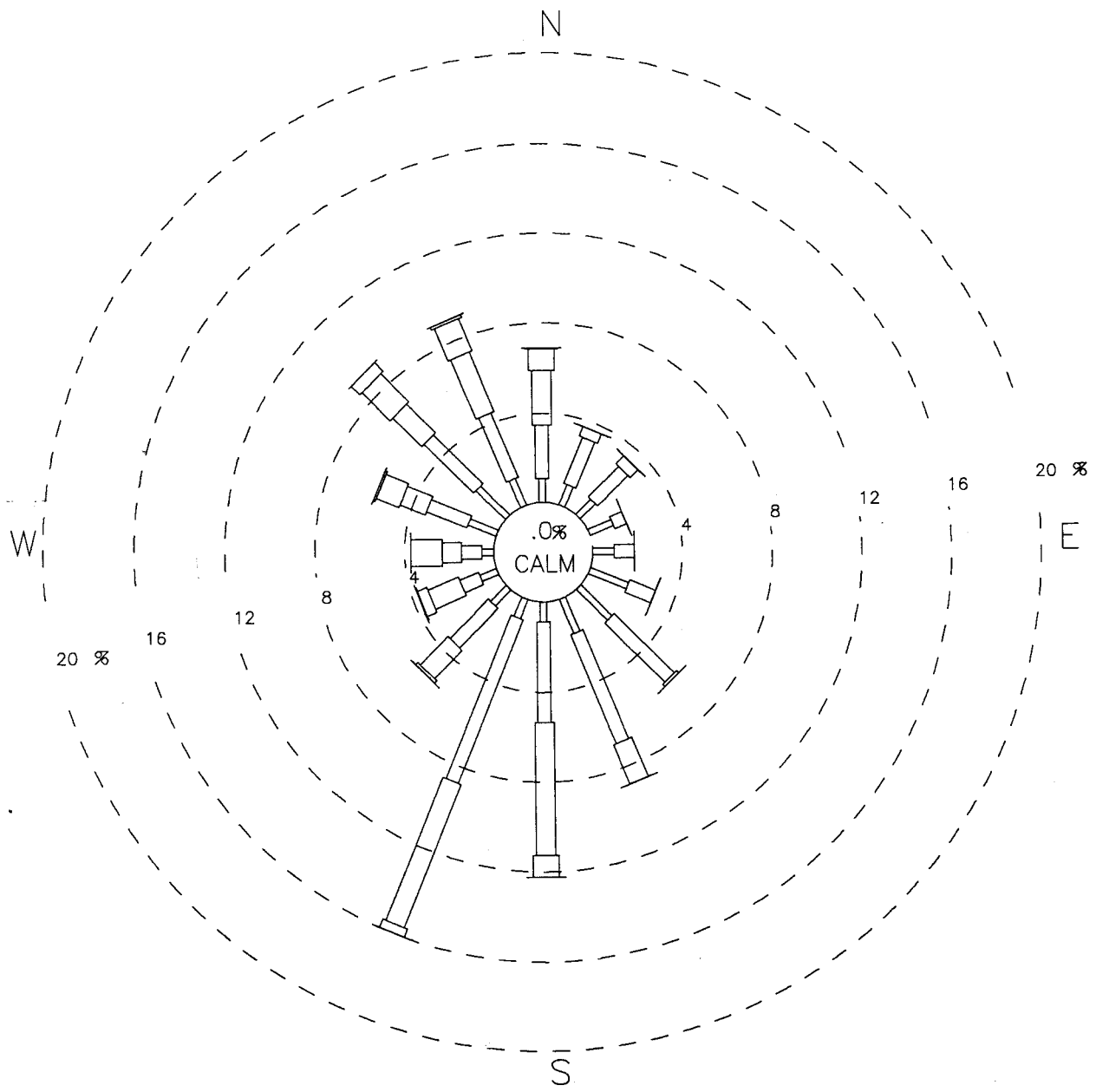
NOTE: WIND DIRECTION IS THE DIRECTION THE WIND IS BLOWING FROM

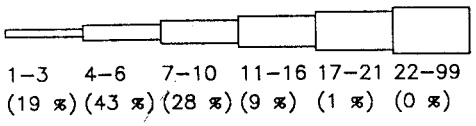
3rd QUARTER 1999 WINDROSE FOR THE WELDON SPRING SITE METEORLOGICAL STATION

FIGURE 1-8

REPORT NO.:	DOE\OR\21548-845	EXHIBIT NO.:	A/PI/005/0599		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/25/00

Wind Direction and Speed Distribution





WIND SPEED SCALE (MPH)

NOTE: WIND DIRECTION IS THE DIRECTION THE WIND IS BLOWING FROM

4th QUARTER 1999 WINDROSE FOR THE WELDON SPRING SITE METEORLOGICAL STATION

FIGURE 1-9

REPORT NO.:	DOE\OR\21548-845	EXHIBIT NO.:	A/PI/006/0599		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/25/00

3.2 km (2 mi) to the northeast. The combined population of these two communities in 1999 was 5,585. No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses (Appendix A).

Francis Howell High School (FHHS) and the Missouri Highway and Transportation Department (MHTD) Weldon Spring maintenance facility are both within 1 km (0.6 mi) of the site (Figure 1-4). Francis Howell High School is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 120 faculty and staff, and about 1,400 students attend school there (Appendix A). Students and staff generally spend about 7 hours to 8 hours per day, 36 weeks per year, at the school. At least 7 employees work at the school year-round. The buildings are also used for other activities, such as athletic events and school meetings. In addition, approximately 53 full-time employees worked at the high school annex during 1999. The MHTD facility, located adjacent to the north side of the chemical plant, employs nine full-time employees (Appendix A).

About 300 ha (741 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park. The conservation areas adjacent to the WSSRAP are operated by the Missouri Department of Conservation and employ about 45 employees. The Army Reserve Training Area is located to the west of the WSSRAP and periodically visited by the Department of Army (DOA) trainees. One DOA full time employee works at the office on the reserve property. During 1999, two full-time employees worked at the Training Area for about eight months (Appendix A).

2. ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

2.1 Project Purpose

The U.S. Department of Energy (DOE) is responsible for the remedial action activities at the Weldon Spring site. The project is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment posed by the waste materials on the Weldon Spring site and, to the extent possible, make surplus real property available for other uses.

Remedial actions are subject to U.S. Environmental Protection Agency (EPA) oversight under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA). Remedial actions at the site are subject to CERCLA requirements because the site is listed on the EPA National Priorities List (NPL). Section 3 of this document further discusses applicable Federal, State, and local compliance requirements and the current status of compliance activities at the Weldon Spring site and incorporating *National Environment Policy Act* (NEPA) values into CERCLA documents as outlined in the DOE Secretarial Policy Statement on NEPA.

2.2 Project Management

In order to manage the WSSRAP under the CERCLA, the proposed strategy for remedial activities at the Weldon Spring site is organized into the following four separate operable units: Weldon Spring Quarry Bulk Waste, Weldon Spring Chemical Plant, Groundwater, and Quarry Residuals. The Weldon Spring Quarry Bulk Waste Operable Unit included all wastes deposited in the quarry and their removal. The Weldon Spring Chemical Plant Operable Unit includes the original chemical plant buildings, contaminated soils, raffinate pits, quarry bulk wastes that were staged at the temporary storage area (TSA), vicinity properties and surface waters within the chemical plant boundary. The Groundwater Operable Unit includes the groundwater at the chemical plant and vicinity areas. The Quarry Residuals Operable Unit includes the quarry proper (post-bulk waste removal), surrounding areas, surface waters, and groundwater.

2.3 Environmental Monitoring Program Overview

The overall goal of the WSSRAP is different from that of most operating and production facilities for which DOE Order 5400.1, *General Environmental Protection Program*, was developed. At the WSSRAP, environmental monitoring is conducted as required by DOE Order 5400.1 to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under CERCLA. This requires a careful integration of WSSRAP activities to implement all the environmental and public health requirements of the CERCLA, DOE orders, and other relevant Federal and State regulations.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance of an *Environmental Monitoring Plan* (EMP) (Ref. 8). The EMP details the schedule and analyses for performing effluent monitoring and surveillance activities.

The WSSRAP environmental protection program involves radiological and chemical environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of contaminants in environmental media at the facility boundary, in contaminant migration pathways, and in pathways subject to compliance with applicable regulations (e.g., National Emission Standards for Hazardous Air Pollutants [NESHAPs]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of site contaminants. The purpose of this surveillance is to detect and/or track the migration of contaminants. Surveillance data are used to assess the presence and magnitude of radiological and chemical exposures and to assess the potential effects to the general public and the environment.

The WSSRAP radiological environmental monitoring program involves sampling various media for radiological constituents; primarily total uranium (U-234, U-235, and U-238), Ra-226, Ra-228, Th-228, Th-230, and Th-232. These radionuclides are the primary radiological contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted routinely at perimeter locations and at off-site locations near the chemical plant and quarry for air particulates, ambient gamma radiation, and radon and thoron gas. Radiological monitoring is also conducted on National Pollutant Discharge Elimination System (NPDES) discharges, streams, lakes, ponds, groundwater and springs.

Chemical environmental monitoring is primarily conducted at the chemical plant and quarry areas, but also includes monitoring at off-site locations to confirm that no releases have occurred. The nonradiological compounds included in the routine 1999 monitoring program are metals, inorganic ions (nitrate and sulfate), and nitroaromatic compounds. Other non-radiological parameters monitored as part of the environmental monitoring program include asbestos at site perimeter air monitoring locations and Francis Howell High School.

2.4 Project Accomplishments in 1999

Several activities were completed in 1999 under the overall plan for remediation of the site. Major accomplishments for the operable units are detailed below.

2.4.1 Weldon Spring Chemical Plant Operable Unit

2.4.1.1 Site Water Treatment Plant

The Site Water Treatment Plant major accomplishments for 1999 include water treatment; operation of the Reverse Osmosis Unit; and operation of the Brine Treatment System.

During 1999 185 million liters (48.9 million gallons) of contaminated water were treated and discharged into the Missouri River. These discharges consistently met the effluent standards set forth in the chemical plant NPDES permit.

The Reverse Osmosis Unit was used to treat high selenium wastewater. The unit treated 42 million liters (11 million gallons) in 11 weeks. The success of this unit allowed the remediation of Raffinate Pits 1, 2, and 4 to begin on an accelerated schedule. Treatment concluded in September 1999.

The Brine Treatment System was constructed to treat brine generated by the Reverse Osmosis Unit. The system was designed to meet *Resource Conservation Recovery Act* (RCRA) treatment and storage requirements, due to the brine being characteristic for selenium. The brine was mixed with a lime/cement mixture and transported to the disposal cell for disposition. The Brine Treatment System treated over 4,100 tons of mixed waste from May 1999 until completion in December 1999.

2.4.1.2 RCRA/TSCA Storage

The RCRA and *Toxic Substances Control Act* (TSCA) facilities include Building 434 and the temporary storage area (TSA).

Activities at Building 434 during 1999 included completion of full-scale chemical stabilization treatment of sodium dichromate waste; shipment of incinerable waste off-site for treatment and disposal; consolidation and management of radioactive waste oil; macroencapsulation treatment of radioactive Ni/Cd batteries and lead security seals; sampling and storage of trinitrotoluene (TNT) pipe and assistance with placement of pipeline in brine grout; carbon adsorption treatment of trichloroethene (TCE)-tainted monitoring well purge water; treatment of radiologically contaminated liquid mercury by amalgamation; bench testing and full-scale process development for carbon adsorption treatment of methylene chloride-tainted wastewater.

Activities at the TSA during 1999 included construction and operation of the Brine Treatment System. In 2000, Building 434 and the TSA will undergo closure in accordance with 40 CFR 264 Subpart G. The planned approach is outlined in the *RCRA Closure Document* (Ref. 7).

2.4.1.3 Disposal Cell

During 1999, Raffinate Pits 3 and 4, the Ash Pond area, and the northern and southern portions of the TSA were successfully remediated. Their associated contaminants were placed in the disposal cell.

Bedding and riprap erosion control protection were installed on the south 3 to 1 slope, and the majority of the east and west 3 to 1 side slopes during 1999. One foot of the clean soil 3-ft radon barrier was also installed over about two-thirds of the cell, from south to north. Only about a third of the cell remains open on the north end to facilitate final clean-up activities.

The WSSRAP-Modified Toxicity Characteristic Leaching Procedure (TCLP) sampling effort was extended to include proposed treatment strategies for residual sludge from Raffinate Pit 4. The final report, *Analytical Results for the WSSRAP-Modified TCLP Test for Disposal Cell Waste,* was issued in July 1999 (Ref. 10).

Semi-annual groundwater compliance monitoring for the disposal cell continued in 1999. Analytical data for this effort can be found in Section 8, *Groundwater Monitoring*.

2.4.1.4 Chemical Stabilization/Solidification Full Scale

Raffinate sludge, which was a waste product from the uranium refining process, was determined to require treatment to form a structurally stable product before it could be placed in the disposal cell. During development of the chemical plant *Record of Decision* (ROD) (Ref. 9), on-site chemical stabilization/solidification (CSS) was identified as the most effective technology for treatment of the contaminated sludge. In this process, fly ash and Portland cement were mixed with the sludge to produce a grout product suitable for permanent placement in the disposal cell.

To provide design data for the full-scale CSS plant, a pilot-scale facility was constructed in 1994 and a comprehensive test program was implemented in 1995. The pilot testing data and related conclusions and recommendations were used to design the full-scale CSS plant. Construction of the full-scale plant was completed in February 1998. Operation began in July 1998 and continued until November 1998.

The CSS Plant was successfully and safely demolished during the spring and summer of 1999. Contaminated portions of the plant were sized and disposed of in the on-site engineered disposal cell. Clean CSS Plant components were sold to outside vendors for reuse in the private sector.

2.4.1.5 Raffinate Pits

Raffinate Pits 1 and 2 were dewatered and the contaminated sludge, sediment, and raffinate were excavated down to firm clay. (Soil from the common berm between Raffinate Pits 1 and 2, plus additional contaminated soils, was blended with the sludge, sediment, and raffinate to meet cell disposal requirements.) The area was characterized by core drillings to determine the extent of remaining contaminated material to be removed in 2000.

Reports entitled *Results of the Engineering Soil Sampling for Weldon Spring Raffinate Pits 3 and 4* (Ref. 19), and *Results of Engineering Soil Sampling for Weldon Spring Raffinate Pits 3 and 4 Addendum 1: Raffinate Pit 4 Phase 2 Additional Sampling Results* (Ref. 32) present the characterization results and were completed in 1999.

2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit

This operable unit was officially closed out in April 1997.

2.4.2.1 Quarry Water Treatment Plant

Beginning in June 1999, after a long-term shutdown, the quarry water treatment plant (QWTP) treated and discharged to the Missouri River approximately 21.2 million liters (5.6 million gallons) of water that met the effluent standards set forth in the NPDES permit for the Weldon Spring Quarry. The quarry sump was successfully dewatered in October 1999.

2.4.3 Weldon Spring Quarry Residuals Operable Unit

The *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* (Ref. 53) was developed during 1999 and finalized in January 2000. This plan is intended to provide the transition from the environmental documentation phase (RI/FS/ROD) to the final design and implementation of the selected remedial action and supporting field studies. The plan describes the criteria for:

- Developing the long-term monitoring system and the institutional controls to be implemented for this operable unit.
- Designing and implementing the interceptor trench field study.
- Addressing residually contaminated soils within the quarry proper.
- Designing the final reclamation for the quarry area.

During 1999, the design for the quarry interceptor trench system (WP-515) was completed. Reclamation of the quarry area is planned as a three-phase project (Tasks WP-513A, WP-513B, and WP-529) consisting of removal of contaminated materials, including structures and soil; restoration of the quarry proper; and dismantlement of the quarry interceptor trench system and quarry water treatment plant. The design for the first phase (WP-513A) was completed during 1999.

The *Record of Decision* (Ref. 11) identified a need to define the extent of radiological soil contamination at two areas in the quarry proper. Removal of soil from these two areas, as well as one additional area, will be performed during quarry restoration activities based on the results of characterization activities performed in 1999 and early 2000. Removal of these soils has been included in the first phase of quarry restoration because of the potential for further reduction in the risk levels in the quarry proper, availability of the on-site disposal cell, and the potential to release the property as surplus. Remediation of these areas is not required by the *Record of Decision* (Ref. 11) because the associated health risks are already within acceptable limits.

2.4.4 Weldon Spring Groundwater Operable Unit

The final *Supplemental Feasibility Study* (Ref. 12) was issued in June 1999. This supplement incorporated the results of the long-term pumping test performed in 1998 into additional evaluations of groundwater remediation alternatives. The *Proposed Plan for Remedial Action* (Ref. 13) was submitted to the public and the regulatory agencies and the public meeting for the Groundwater Operable Unit was held on August 25, 1999 at the Weldon Spring site.

The draft *Record of Decision* was submitted to the regulatory agencies in September 1999. A final decision is pending negotiations with the Environmental Protection Agency, Region VII, and the Missouri Department of Natural Resources.

2.5 Incident Reporting - Environmental Occurrences in 1999

In accordance with DOE Order 5400.1, Chapter II, 2.(b), field organizations are required to prepare annual summary reports on environmental occurrence activities and to report this information in the annual site environmental report.

In 1999, five off-normal occurrences of an environmental nature were reported under DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these environmental occurrences for 1999. Further discussion of each occurrence is provided in the following paragraphs.

Table 2-1 Environmental Occurrences CY 1999

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1999-0006	02/18/99	NPDES permit condition violation.
1999-0010	03/18/99	NPDES permit limit exceedence.
1999-0022	11/03/99	NPDES permit notification level exceedence.
1999-0024	11/24/99	NPDES permit limit exceedence.
1999-0025	12/16/99	Radioactive liquid spill

Occurrence 1999-0006

On Monday, February 15, 1999, a subcontractor decontaminated a backhoe on the access control decontamination pad. It rained early on Tuesday, February 16 (approximately 0.86 cm [.34 of an inch] of rain). The decontamination pad sump overflowed to a storm sewer inlet, impacting storm water outfall NP-0002.

The sump had not been pumped down recently and the water from the precipitation caused it to overflow to a storm water inlet just outside the decontamination pad area. The water remaining in the sump was measured for uranium, and the concentration was determined to be 21.5 pCi/l (0.8 Bq/l), which is well below the storm water discharge administrative level of 600 pCi/l (22 Bq/l). Based on the precipitation and the area of the decontamination pad, it was estimated that approximately 250 liters (65 gal) of water entered the storm sewer from the decontamination pad. No detrimental effects were noted on the receiving stream.

No permit limits were violated; however, outfall NP-0002 is not permitted for decontamination pad water. A letter was sent to the Missouri Department of Natural Resource (MDNR) on February 18, 1999, addressing this incident.

Occurrence 1999-0010

On Monday, March 1, 1999, a full NPDES sample was collected for Batch 154 at the site water treatment plant. The best available turnaround time that could be obtained was 7 days. Waiting for analytical results would have necessitated shutting down the treatment plant due to lack of storage capacity to accumulate additional treatment water. Due to the current backlog of water to be treated and consistent with site procedures, this batch of water was released beginning March 5, based upon extensive process monitoring, including a series of rapid turnaround off-site selenium analyses. The process monitoring indicated the batch was compliant with the parameters monitored. The selenium concentration was approximately 25 µg/l to 30 µg/l based on sample results. Process monitoring for selenium included both daily effluent and composites from the effluent pond. Preliminary results from the full NPDES sample were received late on March 8, 1999. The total selenium result was 55.6 µg/l, which is above the 50 µg/l daily maximum limit. The duplicate result was 55.2 µg/l.

A letter was sent to MDNR on March 12, 1999, addressing the exceedence of the selenium level for the NPDES permit MO-0107701. Further discussions were held among the subcontractor, PMC, DOE, and MDNR, to identify probable causes of the noncompliance, and a follow-up letter was sent to MDNR on April 8, 1999.

Occurrence 1999-0022

On October 8, 1999, a storm water sample was collected at Outfall NP-0051. This outfall was the storm water outlet fed by remediated portions of the TSA. The water was flowing from both the north and south remediated sections to a perforated pipe. The sample was collected from near the north end of the pipe. There was a greater than 2.5 cm (1 in.) rainfall the night before and the flow was approximately 38 lpm (10 gpm). The sample could not be collected directly from the pipe because the water was flowing from holes on the bottom of the pipe, which was in direct contact with the rock bedding. The water was collected about 3 m (10 ft) downslope where it flowed from the rock bedding.

The sample results were received on November 2, 1999, and indicated that the zinc level was 147 µg/l, which was above the 100 µg/l NPDES permit reporting level for toxic pollutants. Total suspended solids were 877 mg/l, which was suspected as being a contributing cause of the elevated zinc. The area has since been seeded and strawed to stabilize the soil and prevent erosion. The NPDES exceedence of a reporting level is required to be reported to the State in writing with 5 days. A letter was sent to MDNR on November 5, 1999, addressing the exceedence of the zinc reporting level for the NPDES permit MO-0107701.

Occurrence 1999-0024

Storm water samples collected at two outfalls were over the limit of 1.0 ml/l/hr for settleable solids. The samples were collected the morning of November 23, 1999 just as an overnight 2.1 cm (0.83 in.) rainfall was ending. The rainfall occurred after a very extended dry period. Settleable solids for Outfall NP-0002 were 34.0 ml/l/hr with a flow of 2,400 lpm (636 gpm) and settleable solids for Outfall NP-0005 were 5.0 ml/l/hr with a flow of 2,060 lpm (544 gpm).

Outfall NP-0002 discharges water from the northeast section of the site including administrative area parking lots and the clean soil covered portions of the cell. The cell area is under construction and is not vegetated. The outer berm is, however, covered with riprap. Runoff from the adjacent highway department facility also contributes to outfall NP-0002 discharge. Effects of runoff from the Highway Department on solids settling have been noted in the past, presumably resulting from storage of road salt. Late in the settleable solids analysis, the salt causes the solids to settle out in a lighter, fluffier layer. Early in the analysis when the heavier particles normally settle out there was no appreciable layer of solids noted.

Outfall NP-0005 discharges water from the south of the site including the treatment plant area. During the sample event the bulk of the flow was water pumped from a sump that was installed to divert water from the cell berm to facilitate construction. This water would normally flow to outfall NP-0003. A letter was sent to MDNR on November 24, 1999, addressing the exceedence of the settleable solids level for the NPDES permit MO-0107701. The areas were seeded and strawed during the middle of October.

Occurrence 1999-0025

On December 14, 1999 at 0845, subcontractor personnel were introducing air into the Train 2 brine transfer pipe in an attempt to blow down the line. According to the subcontractor, the air was being introduced at 120 psi. The PVC pipeline used to transfer brine to the storage tank at the TSA separated at an elbow connection on the top of the tank. Approximately 26 l (7 gal) of contaminated brine was sprayed into an associated secondary containment and approximately 11 l (3 gal) was sprayed onto the graveled area outside of the secondary containment. The graveled area is a radiologically uncontrolled area.

Five subcontractor personnel were in the general work area when the incident occurred. None came in contact with the brine. All five were directed to monitor for contamination by passing through the PCM-2 at the TSA trailer. No contamination was detected on personnel. The contaminated areas were barricaded and properly posted.

Samples were taken of the source of the water and were estimated to contain 389,380 pCi/l (14,420 Bq/l) uranium. This was determined by sampling the material that remained in the pipe, which was a mixture of sediments and liquids from the Train 2 process. (The Train 2 process was used to treat raffinate pit water and produced the brine as a by-product.) The analytical results from the sample indicated a specific activity for uranium of 389.38 pCi/g (14.4 Bq/l). This was converted to a liquid measurement with the following calculation:

$$389.38 \text{ pCi/g} \times 1 \text{ g/ml} \times 1000 \text{ ml/l} = 389{,}380 \text{ pCi/l (14,420 Bq/l)}$$

The system was not operating at the time of the blowdown and was in the process of being dismantled. The area was cleaned up and this material, along with the dismantled pipelines was placed in the disposal cell for final disposal.

2.6 Special DOE Order Related Programs

In addition to the direct program requirements and documentation required under DOE Order 5400.1, the DOE Order specifically requests that other programs be presented in the annual site environment report, including the groundwater protection management program, the meteorological monitoring program, and the waste minimization and pollution prevention program. This section also addresses other programs such as self assessments, the radiological

control program, and the surface water management program at the WSSRAP.

2.6.1 Groundwater Protection Management Program

The WSSRAP has a formal groundwater protection and management program in place. The policies and practices are documented in the WSSRAP *Groundwater Protection Management Program Plan* (Ref. 14). The plan outlines how monitoring programs will be developed to assess the nature and extent of contaminants in the groundwater, to evaluate potential impacts on public health, and to gather data for remedial decisions. All policies pertaining to groundwater monitoring, including well installation, decontamination, construction, sampling methods, and abandonment methods, are detailed in this plan. The plan outlines the hydrogeological characterization program conducted as part of CERCLA activities. These include groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging. The plan also describes strategies for implementing site-wide groundwater protection practices and interdepartmental integration of these practices during all aspects of project management and development.

2.6.2 Meteorological Monitoring Program

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The meteorological station provides data on wind speed, wind direction, wind stability, ambient air temperature, relative humidity, barometric pressure, solar radiation, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which can be used to model impacts of potential airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

Since the completion of a system upgrade in August 1994, meteorological data recovery has exceeded 99% each year. An off-site meteorologist provides monthly data reviews and conducts semiannual maintenance and performance checks for the station.

2.6.3 Surface Water Management Program

The WSSRAP maintains a surface water management program to ensure effective implementation of policies detailed in DOE Order 5400.5 and documented in the *Surface Water Management Plan* (Ref.16) and ES&H 9.1.2, *Surface Water Management*. This program also incorporates the as low as reasonably achievable (ALARA) concept in the execution of the program.

This plan identifies existing and potential water sources, water quality categories, and provides the requirements and methodologies for proper control, management, and disposition of site waters. Erosion and water control, and water management for the quarry and site water

treatment plants are also discussed. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods.

2.6.4 Radiation Protection Program

The U.S. Department of Energy issued 10 CFR 835 (*Occupational Radiation Protection*), in December 1993 in the Federal Register; 10 CFR 835 sets the minimum acceptable occupational radiological control standards for DOE facilities. The regulation includes requirements for contamination control; ALARA practices; internal and external dosimetry; facility design and control; internal surveillances; instrumentation and calibration; worker training, posting and labeling, and release of materials from radiological areas.

As of December 31, 1999, the WSSRAP is in full compliance with all applicable sections of 10 CFR 835.

2.6.5 Waste Management Program

The waste management program encompasses all waste-related activities (both interim and long term) including characterization, treatment, storage, minimization, and disposal performed at the Weldon Spring site by project personnel, subcontractors, and subtier contractors. Hazardous, radioactive, toxic, mixed, special and uncontaminated waste produced as a direct result of project cleanup activities, are within the scope of this program. Garbage and refuse generated as a result of the project administration are excluded.

Waste management activities for 1999 include:

- Completion of full-scale chemical stabilization treatment of sodium dichromate waste.
- Shipment of incinerable waste to Diversified Scientific Services, Inc. (DSSI).
- Consolidation and shipment of radioactive waste oil to DSSI for off-site commercial treatment.
- Macroencapsulation treatment of radioactive Ni/Cd batteries and lead security seals.
- Development and operation of Train 2 brine stabilization and disposal process.
- Sampling of TNT pipe and assistance with placement of pipeline in wet Train 2 brine grout.
- Carbon adsorption treatment of TCE-tainted monitoring well purge water.

- Bench testing and full-scale process development for carbon adsorption treatment of methylene chloride-tainted wastewater.

The waste management program also includes transportation activities such as the packaging and shipping of hazardous and nonhazardous wastes. The following transportation activities took place in 1999:

- In June, two RCRA containers of flammable liquids were shipped to DSSI for off-site treatment and disposal.

- Two shipments totaling 228 kg (612 lbs) of various types of light bulbs were sent off site for recycling.

- Twenty-seven lead and 93 Ni-Cad batteries were sent off site for recycling.

- Twenty-seven shipments totaling 50,700 l (13,400 gallons) of used oil were sent off site for recycling.

2.6.6 Waste Minimization/Pollution Prevention Program

The WSSRAP Waste Minimization Program is outlined in the *Waste Minimization/ Pollution Prevention Awareness Plan* (Ref. 17) in accordance with the requirements of DOE Order 5400.1. Because long-term, volume-specific goals for waste minimization are not appropriate for nonoperational facilities, the WSSRAP has adopted ALARA goals.

The program is primarily geared toward material substitution and source or volume reduction minimization methods. This is accomplished by evaluating and reviewing all hazardous chemicals (as defined by 29 CFR 1926.59) before they are purchased or arrive on site, and recommending alternate materials or applying use restrictions. Additional methods routinely employed at the WSSRAP include removing packaging materials from products before they enter the radioactive materials management areas, limiting waste-generating activities during remediation and treatment, consolidating waste during storage, reviewing design specifications for possible methods to minimize waste generation, and segregating waste by waste types.

The following is a detailed list of the waste minimization activities conducted during 1999.

- The WSSRAP donated approximately 100 personal computer system workstations to a local high school under Executive Order 12821, which allows agencies to transfer educationally related Federal equipment to secondary schools.

- Ninety-three Ni-Cad and 27 lead batteries were sent back to the manufacturer for recycling.

- Approximately 440 m^3 (570 cu yd) of paper/cardboard, 955 kg (2,100 lb) of newspaper and 20,800 aluminum cans were collected by a recycler.

- Approximately 100 used tires were sent to a recycler.

- Approximately 300 toner cartridges were sent back to the manufacturer. Money from recycling cartridges will be donated to the Forestry Department.

- Cotton coveralls used for personal protection are being laundered and reused.

- Seventy-two kilograms (161 lb) of incandescent lamps and 200 kg (459 lb) of fluorescent lamps were shipped to a recycler.

- A total of 50,700 l (13,400 gal) of used oil was sent to a recycler.

- The Reverse Osmosis (RO) treatment system was transferred to WSSRAP from a DOE site located near Monticello, Utah. The system was used at WSSRAP to treat high selenium wastewater. Once treatment was complete the system was sent to a DOE site in Ashtabula, Ohio for use.

3. COMPLIANCE SUMMARY

3.1 Compliance Status for 1999

The Weldon Spring site is listed on the National Priorities List (NPL), and therefore the Weldon Spring Site Remedial Action Project (WSSRAP) is governed by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process. Under the CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements of Federal, State, and local laws and statues, such as the *Resource Conservation and Recovery Act* (RCRA), the *Clean Water Act* (CWA), the *Clean Air Act* (CAA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), *Endangered Species Act*, and Missouri State regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, the *National Environmental Policy Act* (NEPA) values must be incorporated. The requirements of DOE Orders must also be met. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal and State regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

3.1.1 Federal and State Regulatory Compliance

Comprehensive Environmental Response, Compensation and Liability Act

The WSSRAP has integrated the procedural and documentation requirements of the CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and the NEPA, as required by the policy stated in DOE Order 5400.4.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site are managed as required by the RCRA as substantive, applicable, or relevant and appropriate (ARARs). This includes characterization, consolidation, inventory, storage, treatment, disposal, and transportation of hazardous wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that are generated during remedial activities.

A RCRA treatment, storage, and disposal permit is not required at the site since remediation is being performed in accordance with decisions reached under the CERCLA. Section 121(e) of the CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

The RCRA was amended by the *Federal Facility Compliance Act* (FFCA), which was enacted on October 6, 1992. The site treatment plan for mixed waste, which was required by the FFCA was finalized with a consent agreement with the MDNR in October 1995. The *1998 Annual Update to the Site Treatment Plan for the Weldon Spring Site* (Ref. 18) was submitted to the MDNR October 15, 1998. In the update the WSSRAP reported that most of the mixed

wastes had been treated. The actual completion of treatment of the site treatment plan mixed wastes was accomplished on October 23, 1998.

RCRA groundwater monitoring for regulated units is discussed in detail in Chapter 8.

Clean Air Act

CAA compliance requirements pertaining to the site are found in Title I - Nonattainments, Title III - Hazardous Air Pollutants (including National Emission Standards for Hazardous Air Pollutants (NESHAPS), and Title VI - Stratospheric Ozone Protection. NESHAPs dose calculations for 1999 indicate the highest effective dose equivalent at a critical receptor location was 0.33 mrem (0.003 mSv), which is well below the NESHAPs standard of 10 mrem (0.1 mSv).

St. Charles County is classified in the Federal Register of November 6, 1991, 56 FR 215 as a moderate nonattainment area for ozone. As a moderate ozone nonattainment area, the requirements would affect sources emitting nitrogen oxides (NO_x) and volatile organic compounds (VOCs). At present, these sources do not exist at the WSSRAP.

Under Title III, asbestos and radionuclides are hazardous air pollutants. These standards establish criteria for the control of radionuclide and asbestos emissions. WSSRAP programs for radionuclides and asbestos are described in detail in Sections 4 and 6, along with the 1999 status of monitoring.

Clean Water Act

Effluents discharged to waters of the United States are regulated under the *Clean Water Act* (CWA) through regulations promulgated and implemented by the State of Missouri. The Federal government has granted regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP included meeting parameter limits set in four National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring are performed. Section 7 includes additional details on the NPDES programs.

Rivers and Harbors Act

No work activity was conducted during this reporting period that would fall under the jurisdiction of this Act.

Federal Insecticide, Fungicide, and Rodenticide Act

The WSSRAP maintains compliance with the *Federal Insecticide, Fungicide, and Rodenticide Act.* Material Safety Data Sheets are reviewed for all pesticides before they are purchased. The WSSRAP does not currently use restricted-use pesticides and, therefore, does not posses a permit/license to purchase these materials. The WSSRAP meets State requirements for pesticide application, and reviews each application for State licensing requirements.

Department of Transportation

Pursuant to U.S. Department of Transportation (DOT) training requirements, the WSSRAP continues to conduct on-site training on hazardous material transportation. The training targets personnel with responsibilities for hazardous materials transportation. The training covers classification of hazardous materials by shipping names, performance based packaging requirements, requirements for marking, labeling and placarding, and proper segregation and modes of transportation. Retraining is required every 3 years.

Safe Drinking Water Act

The *Safe Drinking Water Act* (SDWA) regulations are not applicable because maximum contaminant levels (MCLs) are applicable only to drinking water at the tap, not in the groundwater. However, under the National Contingency Plan, MCLs are relevant and appropriate to groundwater that is a potential drinking water source.

Emergency Planning and Community Right-to-Know Act

The 1999 *Emergency Planning and Community Right-to-Know Act* (EPCRA) Tier II report was completed and provided on February 1, 2000, to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

The Toxic Release Inventory (TRI) report for 1999 is due on July 1, 2000. At this time WSSRAP expects to submit a TRI report.

Cultural Resources/National Historic Preservation Act

The FY99 Federal Archeological Activities Questionnaire was submitted on February 18, 2000.

The questionnaire summarized the archeological identification and evaluation performed at the WSSRAP during FY99.

Endangered Species Act

There was no activity this reporting period.

3.1.2 DOE Order Compliance

3.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5 establishes primary standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits.

The annual dose to the maximally exposed member of the public as a result of activities at the Weldon Spring site was 2.63 mrem (0.026 mSv), which is well below the 100 mrem (1 mSv) guideline for all potential exposure pathways. The 10 mrem (0.1 mSv) annual dose limit for public exposure to airborne emissions, excluding radon and its respective decay products as specified in 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*, was not exceeded in 1999. The appropriate dose evaluation techniques were used to assess 1999 environmental monitoring and surveillance data in compliance with this requirement.

The annual average uranium concentrations at all NPDES outfalls were below the derived concentration guideline (DCG) of 600 pCi/l (22.2 Bq/l).

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1999 are being maintained in accordance with the requirement of this Order. All reports and records generated at the WSSRAP in 1999, pursuant to DOE Order requirements, presented data in the units specified by the applicable regulation or Order.

3.1.2.2 DOE Order 5400.1, General Environmental Protection Program

The WSSRAP conducted both radiological and nonradiological environmental monitoring programs at the site and vicinity properties. Environmental monitoring required by DOE Order 5400.1 was conducted to measure and monitor effluents and to provide surveillance of their effects on the environment and public health.

The WSSRAP was in compliance with Order 5400.1 requirements for preparation of an *Environmental Monitoring Plan* (Ref. 8) that is reviewed annually and revised as necessary.

In addition to the plans developed for overall environmental monitoring and protection, the WSSRAP annually reviews and revises, as necessary, the *Groundwater Protection*

Management Program Plan (Ref. 14) and the *Waste Minimization and Pollution Prevention Awareness Plan* (Ref. 17). Refer to Section 2.6.6 for additional details.

3.2 Current Issues and Actions

3.2.1 Current Issues

3.2.1.1 National Emission Standards for Hazardous Air Pollutants Compliance

The WSSRAP has developed a critical receptor monitoring program for compliance with the requirements of 40 CFR 61 Subpart H. Point source and environmental monitoring have been mandated per 40 CFR 61.93(b)(5), whereby air concentrations are monitored at seven designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 20), which has been approved by the U.S. Environmental Protection Agency (EPA). The WSSRAP reports annual monitoring results and effective dose equivalents at critical receptor locations via the annual NESHAPs Report. The NESHAPs monitoring program is expected to conclude at the end of 2000 as a result of final waste placement in the onsite disposal cell.

3.3 Summary of Permits for 1999

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-1 provides a summary of all NPDES permits. Four active NPDES operating permits covered discharges from the site water treatment plant (MO-0107701), quarry water treatment plant (MO-0108987), storm water discharges from the Borrow Area and Borrow Area haul road (MO-R100B69), and hydrostatic test water from the site (MO-G670203). An NPDES construction permit for the leachate collection removal system of the cell was issued in January 1997.

3.4 Site Mitigation Action Plan

The progress of the mitigative actions for the remediation of the Weldon Spring site is reported annually in the site environmental report in accordance with DOE Order 5440.1E. The *Mitigation Action Plan (MAP) for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 21), was developed to present planned mitigation actions that provide protection for human health and the environment during remediation activities. The MAP is reviewed and updated annually, as necessary, to reflect site conditions.

Table 3-1 Summary of WSSRAP NPDES and Construction Permits

PERMIT NO.	(a)	DATE ISSUED	DATE EXPIRED	(b)	DATE RENEWAL OR EXTENSION REQUEST DUE	SCOPE AND COMMENTS
MO-0107701	O	03/03/94	03/04/99	Y	Renewal application submitted and pending	Covers storm water, sanitary, and SWTP discharges.
MO-0108987	O	07/17/98	07/16/03	N	01/16/03	Covers QWTP discharge.
MO-R100B69	O	05/29/98	01/02/02	N	07/02/01	Storm water discharges from the Borrow Area and haul road operations.
MO-G670203	O	12/05/97	10/23/02	N	02/23/02	Covers hydrostatic test water at site.
CP-22-5186	C	01/08/97	01/07/02	N	12/07/01	Covers construction of cell leachate collection system.
CP-22-5765	C	06/19/99	06/15/00	N	05/15/00	Covers construction of reverse osmosis unit.

(a) Permit type, O = Operating, C = Construction
(b) Permit renewal application submitted N = No, Y = Yes.
QWTP Quarry water treatment plant
SWTP Site water treatment plant.

Construction activities at the Weldon Spring site are managed by using good engineering practices for control of surface water runoff at, and from, the site. During 1999, four sedimentation basins and four retention ponds were in place at the chemical plant area during soil excavation activities. Surface water protection during 1999 included erosion prevention and sediment control and monitoring. Monitoring was conducted at eight outfall locations at the chemical plant, and the requirements of four NPDES permits and the *Missouri Clean Water Act* were met during 1999. Further information on compliance issues are provided in Section 7.

The wetlands mitigation agreement with the Corps of Engineers (COE) was signed in 1994 to establish a replacement wetland area. Remedial activities at the site have eliminated some wetlands during 1999. The construction of the replacement wetland area was completed in August 1997 at the Busch Memorial Conservation Area in accordance with the mitigation plan. Wetlands monitoring was conducted by the DOE at the mitigation area starting in 1997 and were concluded in 1999. Results of 1999 monitoring are reported in the *Wetlands Monitoring Report for the Weldon Spring Site Remedial Action Project* (Ref. 22).

Topsoils and subsoils from the Borrow Area that are being stored for restoration have been stockpiled at the Borrow Area. Stockpile heights and slopes have been limited to 2.5:1 and stockpiles have been seeded and mulched to control erosion. In 1999, exposed areas at the Borrow Area were reclaimed and seeded with a top seed mix. Erosion control measures are implemented at the Borrow Area and along the haul road. Stockpiles are routinely inspected for erosion. Two sedimentation ponds have been constructed at the Borrow Area, and surface water

has been monitored to measure the effective removal of settleable materials. Specific NPDES compliance details for the Borrow Area are provided in Section 7.

Air, surface water, and groundwater have been monitored as part of the routine environmental activities at the chemical plant area. The results of this monitoring are presented and discussed in the remaining sections of this report.

4. AIR MONITORING PROGRAMS

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental airborne monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders and with the *Environmental Monitoring Plan* (Ref. 8). This section describes monitoring results for radon, gamma exposure, airborne radioactive particulates, airborne asbestos, and fine particulate matter at various site perimeter and off-site locations. A program overview, summary of applicable standards, actual monitoring results, and an assessment of any associated environmental impacts are provided below for each parameter mentioned in the plan.

4.1 Highlights of Air Monitoring

- Statistical analysis at the 95% confidence level indicated that one integrated radon alpha track monitoring station within the site boundary exceeded the annual average background concentration in 1999. No annual integrated radon alpha track results at perimeter or critical receptor locations were statistically greater than background levels.

- Statistical analysis at the 95% confidence level indicated that three modified Rn-220 (thoron) alpha track monitoring locations exceeded 1999 average background levels. These stations are all located within the site boundary.

- Environmental thermoluminescent dosimeter (TLD) results for 1999 at the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 46.6 mrem/year (0.47 mSv/year) to 72.9 mrem/year (0.73 mSv/year). These results are inclusive of background, which totaled 56.9 mrem (0.57 mSv) for the year. Statistical analysis of the results indicate that, at the 95% confidence level, two chemical plant/raffinate pit perimeter stations exceeded background levels. These two stations exceeded the annual background exposure by 10.7 mrem (0.11 mSv) to 16.0 mrem (0.16 mSv).

- Statistical analysis at the 95% confidence level indicated that eight low-volume radioactive airborne particulate monitoring stations along the chemical plant perimeter had annual average concentrations that exceeded the 52-week background average. These eight stations, which measure gross alpha airborne concentrations, exceeded the 52-week background average by 2.6E-16 μCi/ml (9.6E-12 Bq/ml) to 6.5E-16 μCi/ml (2.4E-11 Bq/ml).

- All 1999 radiological air monitoring results at Francis Howell High School (including radon, gamma exposure, and airborne radioactive particulates) were indistinguishable from background.

- All asbestos monitoring conducted during 1999 indicated fiber concentrations of less than 0.01 fibers/ml air.

4.2 Radon Gas Monitoring Program

4.2.1 Program Overview

Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. Radon gases (i.e., Rn-222, radon and Rn-220, thoron) are naturally occurring radioactive gases found in the U-238 and Th-232 decay series, respectively. A fraction of the radon produced from the radioactive decay of U-238 and Th-232 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon and thoron gases are produced at the Weldon Spring site from these natural sources as well as from the contaminated waste materials present at the site.

Airborne radon and thoron concentrations are governed by source strength and dilution factors, both of which are strongly affected by meteorological conditions. The soil surface constitutes the largest source of radon and thoron, although secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon and thoron levels in the atmosphere have been observed to vary with height above the ground, season, time of day, and location. The chief meteorological parameter governing airborne radon and thoron concentrations is atmospheric stability; however, the largest variations in atmospheric radon and thoron occur spatially (Ref. 23).

Two types of alpha track detectors are used at the WSSRAP to measure ambient levels of radon gas: standard "F-type" detectors, which measure a combination of radon and thoron gas (results are termed "integrated"), and modified "M-type" detectors, which indirectly indicate ambient levels of thoron only. F-type and M-type alpha track detectors are used in conjunction to distinguish radon and thoron concentrations by analyzing the relative response of paired sets of these detectors at each monitoring location where they are deployed.

In 1999, a pair of standard F-type alpha track detectors was deployed quarterly at each of 32 permanent monitoring locations: 11 at the Weldon Spring Chemical Plant perimeter, two at the Weldon Spring Quarry perimeter, 12 inside the site boundary, and seven at off-site locations. Alpha track monitoring locations are identified with an "RD" prefix in Figures 4-1 through 4-4.

Monitoring locations are distributed around the chemical plant, raffinate pits, and quarry perimeters to ensure adequate detection of radon and thoron under varying meteorological conditions. Locations RD-4005 and RD-4009 monitor background radon and thoron concentrations. F-type alpha track detectors are sensitive to all isotopes of radon and are deployed quarterly.

Paired M-type alpha track detectors were deployed quarterly in 1999 at 30 monitoring locations: 11 at the chemical plant perimeter, one at the quarry perimeter, 11 inside the site boundary, and seven at off-site locations (including two background locations, RD-4005 and RD-4009). Specific locations are identified on Figures 4-1 through 4-4. These detectors were

placed in conjunction with F-type alpha track detectors to distinguish radon from thoron concentrations. Using Pearson's method (Ref. 24) (Pearson et al), separate concentrations of radon and thoron were calculated for these stations.

The WSSRAP radon monitoring program also uses electret detectors, which provide more timely data (biweekly) than the alpha track detectors (quarterly). Like alpha track detectors, electret detectors provide a passive means of measuring radon and thoron gas concentrations in air. Twenty-nine pairs of electret detectors that measure radon only were placed at the following monitoring locations: 26 in the chemical plant area (including seven along the site perimeter), and three off site. Twenty-one pairs of electrets that indicate thoron concentrations were deployed at the following locations: 14 in the chemical plant area, and three off site (including one background location, ET-4009). Electrets are exchanged and read biweekly. These locations, designated by an "ET" prefix, are shown in Figures 4-1 through 4-5.

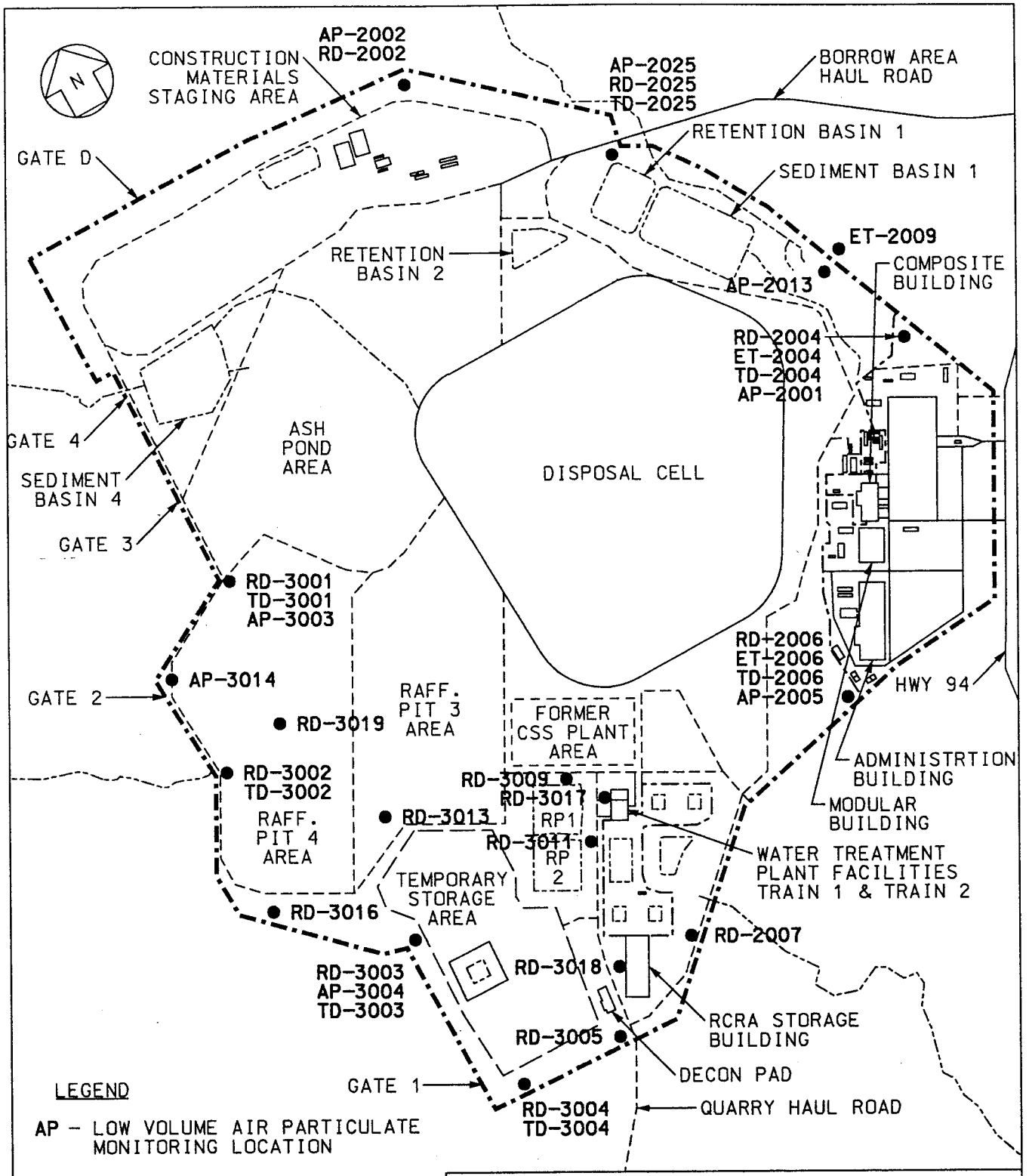
Continuous radon gas monitors and working level monitors (which measure radon and thoron daughters in the air) complete the environmental radon monitoring network. Continuous radon gas monitors are sensitive to both radon and thoron. Continuous radon gas monitors were placed in on-site work zones throughout the year to evaluate local airborne levels of radon and thoron present as a result of remediation activities. In 1999, monitors were placed at Train 2 of the site water treatment plant (SWTP).

Working level monitors are sensitive to the short-lived decay products of radon and thoron. Results are recorded in milli-working levels (mWL). Working level monitors are used in work zones in conjunction with continuous radon gas monitors to determine the degree of equilibrium of radon (or thoron) gas with its decay products and the potential radon or thoron progeny dose to workers. The working level monitors operated in 1999 alongside the continuous radon gas monitors at Train 2 of the SWTP.

4.2.2 Applicable Standards

As established by DOE Order 5400.5, the DOE annual public dose equivalent limit is 100 mrem (1 mSv) total effective dose equivalent (TEDE).

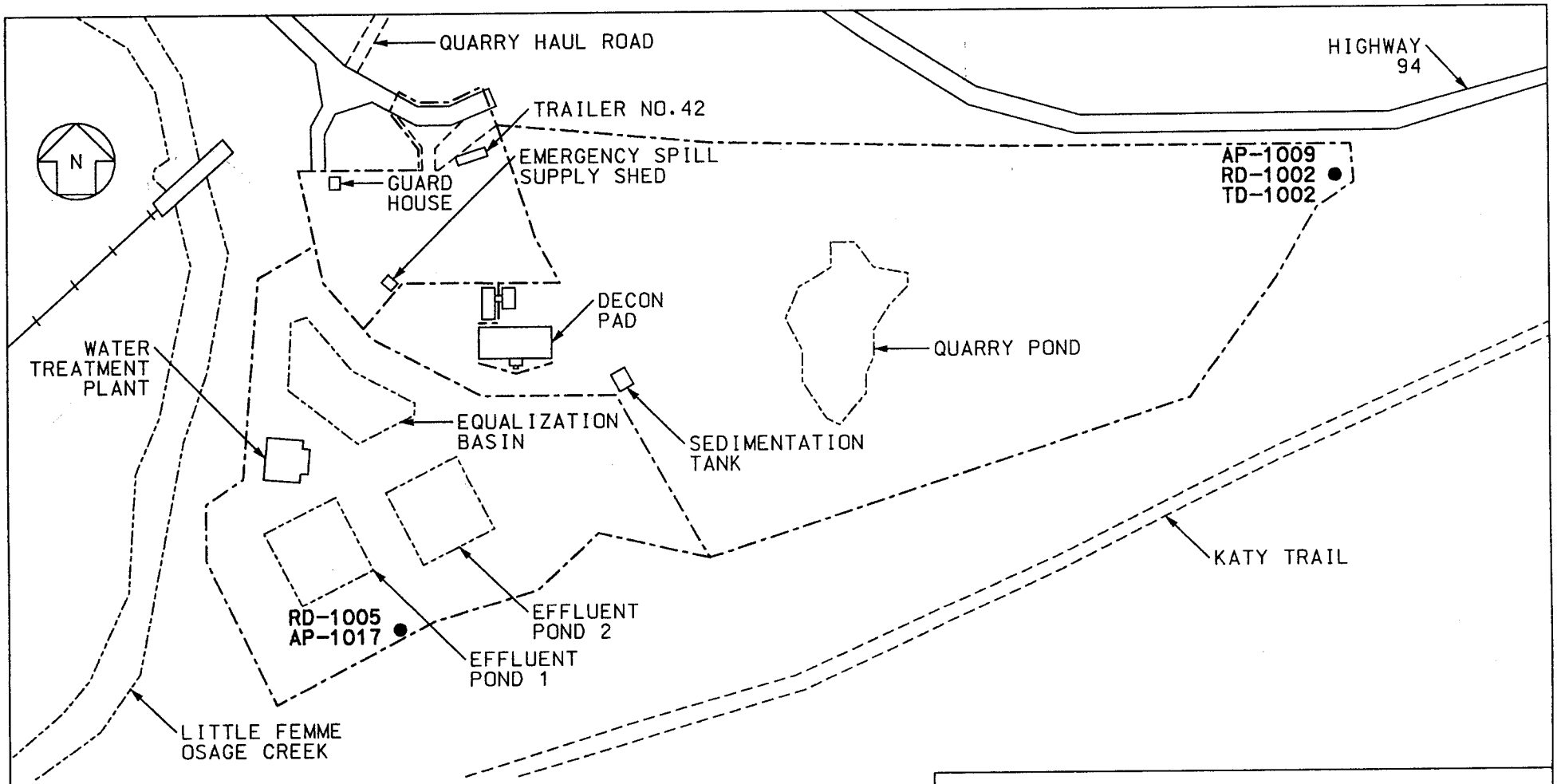
Dose limits for the inhalation of radon and thoron progeny and gas, are based on working levels and concentrations in air, and are addressed independently in the Order. The DCG, which is a limiting airborne concentration of a specified radionuclide, is specified by DOE 5400.5 to be 3 pCi/l (100 Bq/m^3) above background for both radon and thoron in unrestricted (off-site) areas.



AIR MONITORING LOCATIONS AT THE CHEMICAL PLANT AREA

FIGURE 4-1

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/CP/042/0694		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	5/22/00



LEGEND

AP – LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD – ALPHA TRACK RADON GAS MONITORING LOCATION

ET – ELECTRET RADON GAS MONITORING LOCATION

TD – GAMMA RADIATION MONITORING LOCATION

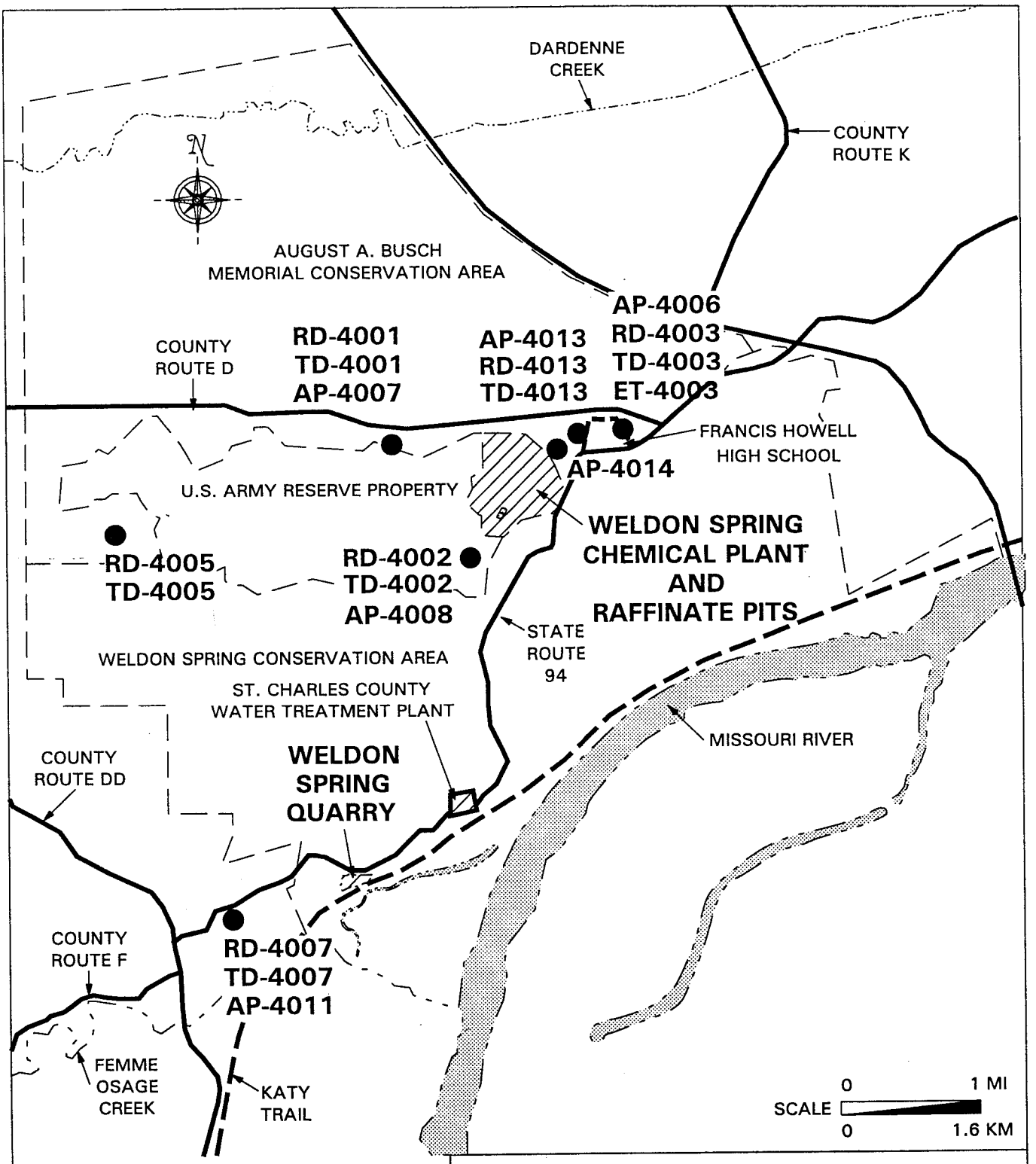
0 200 400

SCALE FEET

AIR MONITORING LOCATIONS AT THE QUARRY AREA

FIGURE 4-2

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/QY/059/1194		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	5/11/00



LEGEND

AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD - ALPHA TRACK RADON GAS MONITORING LOCATION

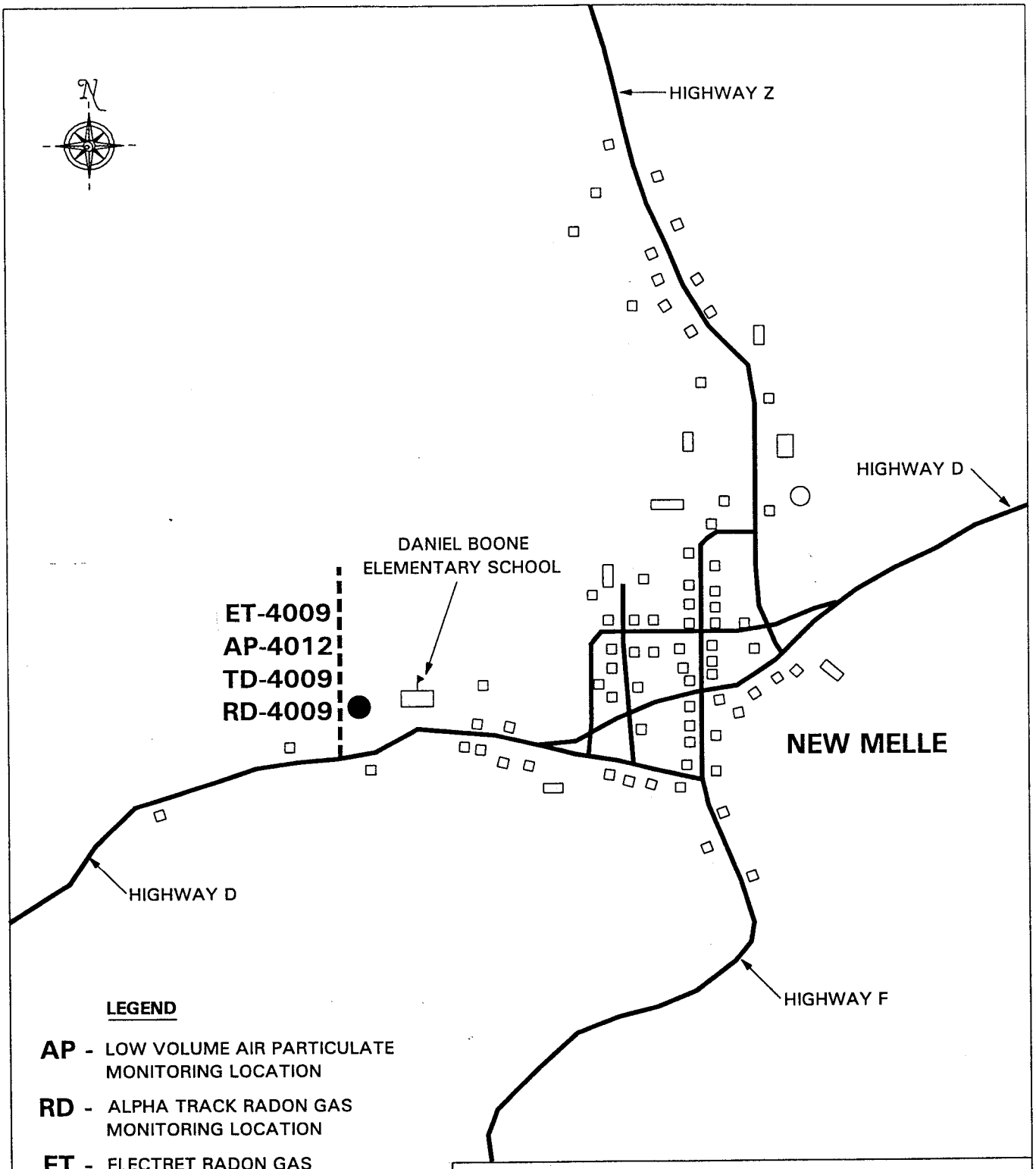
ET - ELECTRET RADON GAS MONITORING LOCATION

TD - GAMMA RADIATION MONITORING LOCATION

OFF-SITE AIR MONITORING LOCATIONS

FIGURE 4-3

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/048/1194		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	5/11/00



LEGEND

AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD - ALPHA TRACK RADON GAS MONITORING LOCATION

ET - ELECTRET RADON GAS MONITORING LOCATION

TD - GAMMA RADIATION MONITORING LOCATION

0 .125 .25 MI

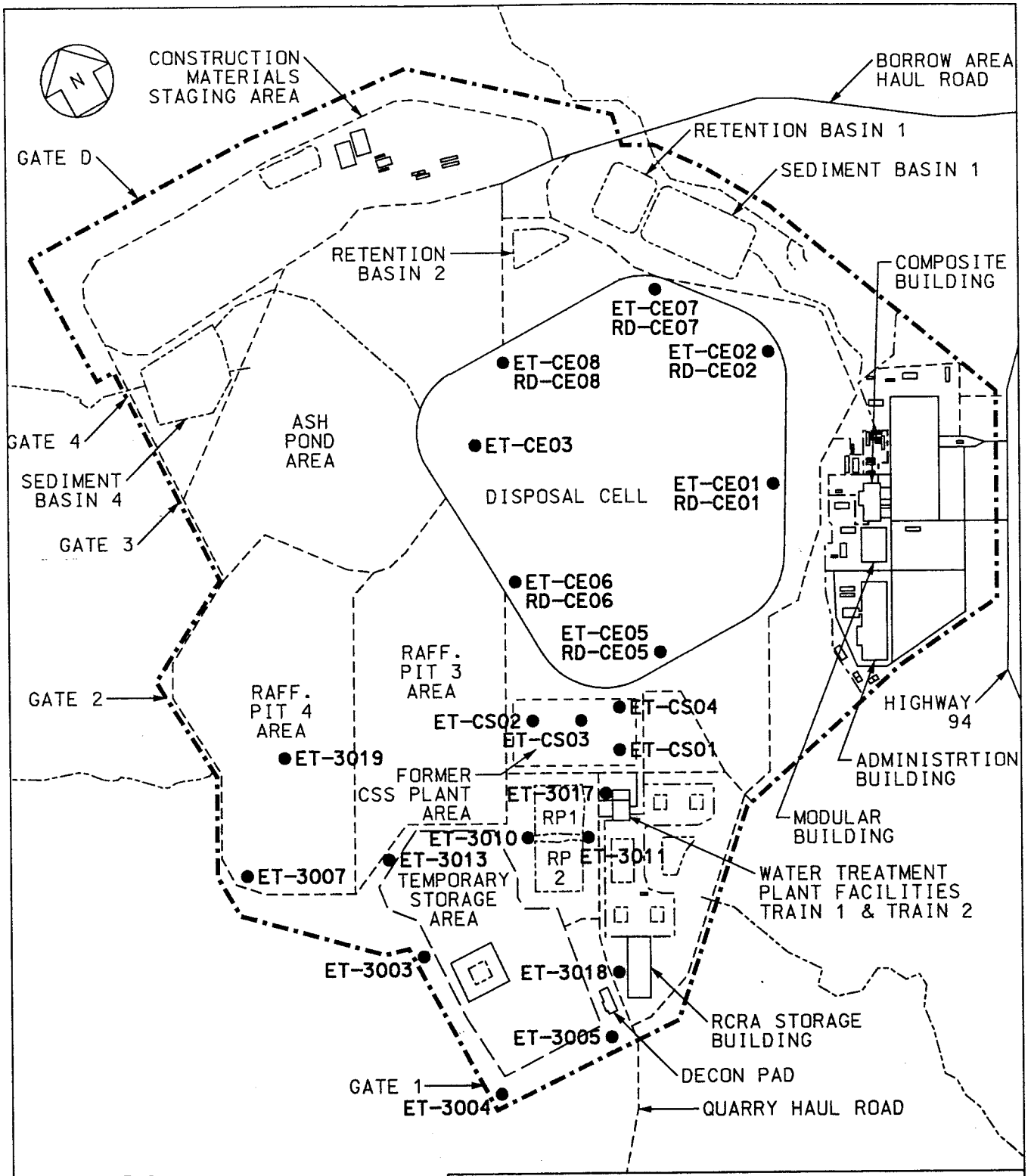
0 .0381 .0762 KM

SCALE

BACKGROUND AIR MONITORING STATION

FIGURE 4-4

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/049/1194		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	5/11/00



LEGEND

RD – ALPHA TRACK RADON GAS MONITORING LOCATION

ET – ELECTRET RADON GAS MONITORING LOCATION

0 600 1200

SCALE FEET

ELECTRET AND RADON MONITORING LOCATIONS IN THE DISPOSAL CELL AND RAFFINATE PIT AREAS

FIGURE 4-5

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/CP/029/0500		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	5/22/00

4.2.3 Monitoring Results

Table 4-1 summarizes quarterly and annual average integrated radon concentrations as measured by F-type alpha track detectors. Since radon is naturally occurring, concentrations measured at each monitoring location were compared to measured background concentrations to determine whether any significant differences existed at the 95% confidence level. Only perimeter locations with integrated radon concentrations statistically greater than background are compared to the DCG for radon by subtracting the average annual background concentration from the gross annual average concentration measured at a given location.

The results obtained from the pair of F-type alpha track detectors at each location were averaged to determine the quarterly average integrated radon concentration. These averages were then used to calculate the annual average integrated radon concentration. The annual standard deviation reported reflects the error propagated by taking the sample standard deviation of the mean of each of the quarterly results.

The annual F-type alpha track background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average integrated radon concentration in 1999 of 0.3 pCi/l (11.1 Bq/m^3). This result is consistent with previous years' monitoring results.

Based on measurements from F-type and M-type alpha track detectors at locations where the potential for a combined release of radon and thoron was suspected, thoron concentrations were estimated using Pearson's method. Results are presented in Table 4-2.

The annual thoron background concentration was determined to be 0.1 pCi/l (4 Bq/m^3) and was calculated using the arithmetic average of the two background locations. This result is consistent with previous years' monitoring results.

Although results in Tables 4-1 and 4-2 may appear inconsistent for a given monitoring location, this is to be expected since F-type detectors have a higher response function for radon than for thoron. The supplemental thoron measuring technique using the M-type detectors provides a better estimate of the thoron contribution to the total radon concentration. Therefore, for monitoring stations where virtually all of the integrated radon concentration is contributed by thoron (for example, see results for RD-3013 in Tables 4-1 and 4-2), the thoron results using Pearson's method are larger than the respective integrated results.

Radon and thoron concentrations measured by the electret monitors are summarized in Tables 4-3 and 4-4. Because electret results are obtained biweekly rather than quarterly (as with the alpha track detectors), they are used primarily as advance indicators of trends in radon/thoron levels at a given monitoring location. Therefore, alpha track results, rather than electret results, are used in performing off-site dose calculations.

Table 4-1 1999 Alpha Track Integrated Radon Results[a]

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT(X) [c]	PERCENT OF GUIDELINE[d]
QUARRY STATIONS								
RD-1002	0.4	0.3	0.5	0.9	0.5	0.26		N/A
RD-1005	0.3	0.1	0.4	0.7	0.4	0.25		N/A
CHEMICAL PLANT PERIMETER STATIONS								
RD-2002	0.3	0.1	0.4	0.8	0.4	0.29		N/A
RD-2004	0.2	0.2	0.4	0.5	0.3	0.15		N/A
RD-2006	0.2	0.2	0.4	0.3	0.3	0.10		N/A
RD-2007	0.3	0.1	0.4	0.7	0.4	0.25		N/A
RD-2025	0.3	0.2	--	--	0.3	0.07		N/A
RD-3001	0.4	0.2	0.3	0.5	0.4	0.13		N/A
RD-3002	0.3	0.1	0.6	0.6	0.4	0.24		7
RD-3003	1.1	0.4	0.8	0.6	0.7	0.30		N/A
RD-3004	0.2	0.1	0.5	0.6	0.4	0.24		N/A
RD-3005	0.3	0.2	0.4	0.5	0.4	0.13		N/A
RD-3016	1.4	0.2	0.6	0.5	0.7	0.51		N/A
STATIONS INSIDE CHEMICAL PLANT BOUNDARY								
RD-3009	0.1	0.3	0.6	--	0.3	0.25		N/A
RD-3011	--	--	--	0.6	0.6	N/A		N/A
RD-3013	2.3	3.9	--	--	3.1	1.13	X	N/A[e]
RD-3017	0.3	0.1	0.2	0.5	0.3	0.17		N/A
RD-3018	0.2	0.2	0.4	0.4	0.3	0.12		N/A
RD-3019	1.0	--	--	--	1.0	N/A		N/A
RD-CE01	1.0	--	--	--	1.0	N/A		N/A
RD-CE02	3.0	--	--	--	3.0	N/A		N/A
RD-CE05	0.9	--	--	--	0.9	N/A		N/A
RD-CE06	1.1	--	--	--	1.1	N/A		N/A
RD-CE07	--	1.3	2.2	1.8	1.8	0.45		N/A
RD-CE08	--	2.0	2.7	--	2.4	0.49		N/A

Table 4-1 1999 Alpha Track Integrated Radon Results [a] (Continued)

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X) [c]	PERCENT OF GUIDELINE[d]
OFF-SITE STATIONS								
RD-4001	0.1	0.1	0.5	0.2	0.2	0.19		N/A
RD-4002	0.1	0.1	0.3	0.6	0.3	0.24		N/A
RD-4003	0.2	0.1	0.3	0.6	0.3	0.22		N/A
RD-4005*	0.2	0.1	0.4	0.4	0.3	0.15		N/A
RD-4007	0.2	0.1	0.3	0.5	0.3	0.18		N/A
RD-4009*	0.2	0.1	0.4	0.6	0.3	0.22		N/A
RD-4013	0.2	0.2	--	--	0.2	0.0		N/A

(a) Results include natural background levels except where otherwise noted.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d) Percent of guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE concentration guideline for Rn-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(e) No percentage calculation performed for above-background monitoring locations within the site boundary.
* Background station.
N/A No percentage calculation performed for background locations or locations not statistically greater than background.
-- No measurement taken.

Table 4-2 1999 Alpha Track Rn-220 Concentrations [a]

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X)[c]	PERCENT OF GUIDELINE[d]
QUARRY STATIONS								
RD-1002	0.3	0.0	0.3	0.1	0.2	0.15		N/A
CHEMICAL PLANT STATIONS								
RD-2002	0.2	0.0	0.0	0.0	0.1	0.1		N/A
RD-2004	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-2006	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-2007	0.3	--	0.0	0.0	0.1	0.17		N/A
RD-2025	0.1	0.0	--	--	0.1	0.07		N/A
STATIONS INSIDE CHEMICAL PLANT BOUNDARY								
RD-3001	0.4	0.0	0.0	0.1	0.1	0.19		N/A
RD-3002	0.2	0.0	0.1	0.0	0.1	0.10		N/A
RD-3003	1.3	0.0	0.4	0.2	0.5	0.57		N/A
RD-3004	0.1	0.0	0.0	0.0	0.0	0.05		N/A
RD-3005	0.0	0.0	0.1	0.0	0.0	0.05		N/A
RD-3016	1.9	0.0	0.3	0.0	0.6	0.91		N/A
RD-3009	0.0	0.0	--	--	0.0	0.0		N/A
RD-3013	1.8	3.8	--	--	2.8	1.41	X	N/A[e]
RD-3017	0.1	0.0	0.0	0.0	0.0	0.05		N/A
RD-3018	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-3019	0.6	--	--	--	0.6	N/A		N/A
RD-CE01	1.0	--	--	--	1.0	N/A		N/A
RD-CE02	3.7	--	--	--	3.7	N/A		N/A
RD-CE05	0.6	--	--	--	0.6	N/A		N/A
RD-CE06	1.0	--	--	--	1.0	N/A		N/A
RD-CE07	--	1.2	2.1	1.4	1.6	0.47	X	N/A[e]
RD-CE08	--	1.9	3.0	--	2.5	0.78	X	N/A[e]

Table 4-2 1999 Alpha Track Rn-220 Concentrations [a] (Continued)

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X)[c]	PERCENT OF GUIDELINE[d]
OFF-SITE STATIONS								
RD-4001	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-4002	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-4003	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-4005*	0.0	0.0	0.1	0.0	0.0	0.5		N/A
RD-4007	0.0	0.0	0.0	0.0	0.0	0.0		N/A
RD-4009*	0.1	0.0	0.2	0.1	0.1	0.08		N/A
RD-4013	0.0	0.0	0.0	0.0	0.0	0.0		N/A

* Background station
(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual average background concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d) Percent of guideline is calculated by taking the annual station average minus the annual average of the background station, divided by the DCG for Rn-220 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(e) No percentage calculation performed for above-background monitoring locations within site boundary.
N/A No percent of guideline calculated for background stations or stations not statistically greater than background.
-- Discontinued or new monitoring location; no data for this quarter.

Table 4-3 1999 Electret Radon-222 Results[a]

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
WELDON SPRING CHEMICAL PLANT						
ET-2004	0.2	0.3	0.5	0.5	0.3	0.15
ET-2006	0.1	0.2	0.3	0.3	0.2	0.16
ET-2008	0.1	0.1	0.1	--	0.1	0.06
ET-2009	0.3	0.4	0.7	0.6	0.5	0.22
WELDON SPRING RAFFINATE PITS						
ET-3003	0.1	0.2	0.4	0.3	0.3	0.11
ET-3004	0.1	0.2	0.4	0.4	0.3	0.15
ET-3005	0.0	0.1	0.3	0.3	0.2	0.14
ET-3007	0.2	0.2	--	--	0.2	0.05
ET-3008	0.4	--	--	--	0.4	0.34
ET-3010	0.1	0.2	0.3	0.3	0.2	0.12
ET-3011	--	--	--	0.3	0.3	0.16
ET-3013	0.1	0.2	--	--	0.1	0.08
ET-3014	0.2	--	--	--	0.2	0.08
ET-3017	0.1	0.2	0.2	0.2	0.2	0.10
ET-3018	0.1	0.2	0.3	0.2	0.2	0.11
ET-3019	0.2	--	--	--	0.2	0.05
CSS FACILITY						
ET-CS01	0.1	0.2	0.3	--	0.2	0.08
ET-CS02	0.2	--	--	--	0.2	0.07
ET-CS03	0.2	--	--	--	0.2	0.04
ET-CS04	0.2	--	--	--	0.2	0.06
DISPOSAL CELL						
ET-CE01	0.2	--	--	--	0.2	0.08
ET-CE02	0.1	--	--	--	0.1	0.08
ET-CE05	0.2	--	--	--	0.2	0.05
ET-CE06	0.2	--	--	--	0.2	0.07
ET-CE07	--	0.2	0.3	0.3	0.2	0.14
ET-CE08	--	0.2	0.2	--	0.2	0.10
OFF-SITE						
ET-4003	0.2	0.3	1.0	0.5	0.5	0.40
ET-4009*	0.1	0.2	0.4	0.4	0.3	0.14
ET-4013	--	--	0.3	0.2	0.3	0.09

(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.
-- Measurement not collected.

Table 4-4 1999 Electret Radon-220 Results[a]

LOCATION ID	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
WELDON SPRING CHEMICAL PLANT						
ET-2004	0.3	0.4	0.3	0.7	0.4	0.30
ET-2009	0.2	0.5	1.0	0.6	0.6	0.51
WELDON SPRING RAFFINATE PITS						
ET-3003	1.2	0.5	0.6	0.6	0.7	0.58
ET-3007	1.1	--	--	--	1.1	0.75
ET-3010	1.0	0.6	0.4	0.7	0.6	0.46
ET-3011	--	--	--	0.8	0.8	0.47
ET-3013	2.8	3.9	--	--	3.4	2.35
ET-3019	2.0	--	--	--	2.0	1.97
CSS FACILITY						
ET-CS01	0.5	0.3	--	--	0.4	0.21
ET-CS02	0.7	--	--	--	0.7	0.28
ET-CS03	0.4	--	--	--	0.4	0.30
ET-CS04	0.3	--	--	--	0.3	0.07
DISPOSAL CELL						
ET-CE01	0.7	--	--	--	0.7	0.22
ET-CE02	0.6	--	--	--	0.6	0.39
ET-CE05	0.9	--	--	--	0.9	0.34
ET-CE06	1.1	--	--	--	1.1	0.71
ET-CE07	0.8	2.8	2.8	2.0	2.5	1.32
ET-CE08	4.2	4.5	3.4	--	4.0	1.51
OFF-SITE						
ET-4003	0.3	0.2	0.4	0.4	0.3	0.18
ET-4009*	0.3	0.4	0.4	0.4	0.3	0.20
ET-4013	--	--	0.4	0.5	0.5	0.24

(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.
N/A No standard deviation calculated.
-- Discontinued or new monitoring location; no data for this quarter.

Historical average background concentrations of radon and thoron gas near the site are both typically 0.2 pCi/l (7 Bq/m^3). Data collected with continuous radon and working level monitors are sporadic throughout the year because they are collected only during activities that have the potential to result in significant worker doses due to inhalation of radon and thoron progeny. Measurements made at the SWTP during 1999 indicated radon and thoron levels at or near background.

4.2.4 Data Analysis

Statistical analysis of the alpha track radon results indicated that, at the 95% confidence level, the measured concentration at one of the 32 monitoring locations was greater than the

combined background result. This station, RD-3013, was located just north of the TSA. The results for other stations were not statistically distinguishable from background levels.

Statistical analysis of alpha track thoron results indicated that, at the 95% confidence level, the annual average concentration at 3 of the 25 monitoring locations exceeded background levels. Two of these stations, RD-CE07 and RD-CE08, are located at the disposal cell. The other station, RD-3013 was located near the TSA. Results for all other stations were statistically indistinguishable from background levels.

4.2.4.1 Chemical Plant and Raffinate Pits

Statistical analysis of one radon alpha track monitoring location, RD-3013, indicated a result greater than background. The annual average concentration for this station exceeded background by 2.8 pCi/l (104 Bq/m^3). With the exception of the immediate vicinity of the disposal cell, radon results in most areas were lower than in previous years, and are likely due to the removal of most contaminated materials from site areas to the disposal cell. The quarterly measured radon concentrations for all stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 3.9 pCi/l (144 Bq/m^3).

Statistical analysis of three thoron track etch monitoring locations, RD-3013, RD-CE07, and RD-CE08, indicated annual average results greater than background levels. The annual average concentration for these stations exceeded the annual average background by 1.3 pCi/l (48 Bq/m^3) to 2.5 pCi/l (93 Bq/m^3). The quarterly thoron measurements for all stations ranged from 0 pCi/l (0 Bq/m^3) to 3.8 pCi/l (141 Bq/m^3). Just as with the integrated radon results, these results are lower than in previous years due to the removal of most contaminated material from site areas into the disposal cell.

4.2.4.2 Quarry

Statistical analysis of track etch radon and thoron monitoring results from the two quarry stations indicated that, at the 95% confidence level these results did not exceed background levels. The quarterly measured results for integrated radon from both quarry stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.9 pCi/l (33 Bq/m^3). Quarterly Rn-220 results at the quarry station ranged from 0 pCi/l (0 Bq/m^3) to 0.3 pCi/l (11 Bq/m^3).

4.2.4.3 Off-Site Locations

Statistical analysis of both track etch integrated radon and thoron monitoring results from off-site locations (shown in Figure 4-3) indicated that there was no reason to suspect, at the 95% confidence level, that measured concentrations at any of the stations were greater than background levels. The quarterly integrated radon concentration measurements at off-site locations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.6 pCi/l (22 Bq/m^3). Quarterly results for thoron

at the off-site stations ranged from 0 pCi/l (0 Bq/m^3) to 0.2 pCi/l (7.4 Bq/m^3). These results are similar to results obtained during previous years.

4.2.4.4 Five-Year Trend Analysis of Integrated Radon Gas

Figure 4-6 shows 5 years of annual average alpha track integrated radon concentrations for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. Radon levels in the raffinate pits area trended upward from 1998 to 1999 likely due to excavation of residual sludge pockets in Raffinate Pit 3. However, all results were well below the DCG of 3 pCi/l for radon and thoron gas. No other trends were evident.

4.3 Gamma Radiation Monitoring

4.3.1 Program Overview

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation-emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise the majority of natural gamma background radiation. The National Council on Radiation Protection and Measurements (NCRP) estimates the typical gamma radiation dose is 28 mrem/year (0.28 mSv/year) from terrestrial sources and 27 mrem/year (0.27 mSv/year) from cosmic sources (Ref. 15). The total estimated background radiation dose equivalent due to gamma exposure is thus 55 mrem/year (0.55 mSv/year).

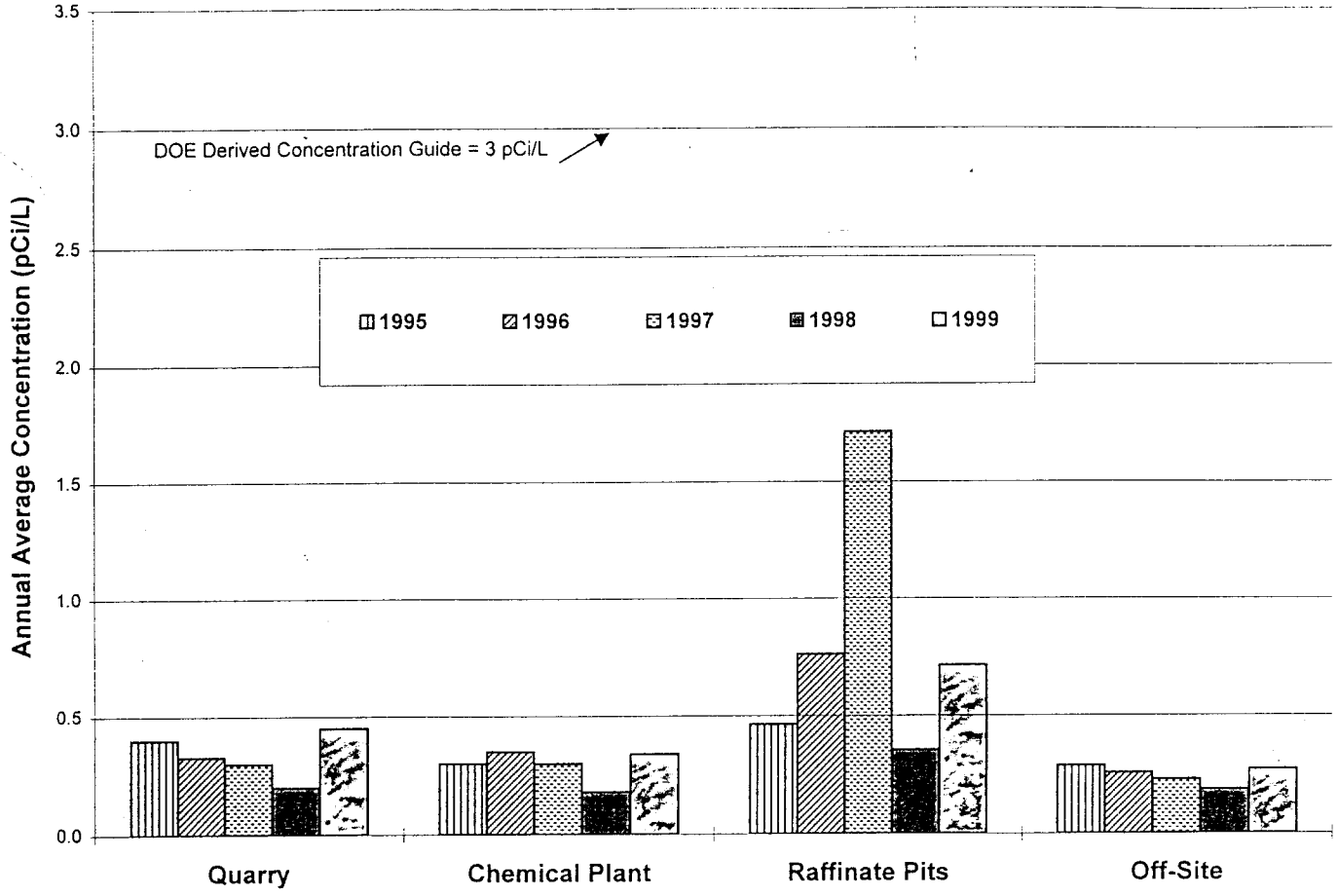
Gamma radiation was monitored in 1999 using TLDs at 15 monitoring stations: seven at the site perimeter, one at the quarry perimeter, and seven off site. The locations are denoted by a "TD" prefix on Figures 4-1 through 4-5. Stations TD-4005 and TD-4009 measure natural background at locations unaffected by the site. The TLDs are exchanged and read every calendar quarter.

4.3.2 Applicable Standards

No specific standard for gamma radiation is stated in the DOE orders. However, DOE Order 5400.5 specifies that members of the public shall receive less than 100 mrem/year (1.0 mSv/year) total effective dose equivalent (TEDE) from DOE operations for all exposure pathways, excluding exposure to natural background radiation.

4.3.3 Monitoring Results

Table 4-5 summarizes quarterly and annual total gamma radiation monitoring results. The table includes quarterly results, annual totals, and the annual sample standard deviation for



RADON TRACK ETCH DETECTOR 5-YEAR TRENDS

FIGURE 4-6

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each station, and indicates whether a station's annual monitoring results are statistically distinguishable from background levels as determined by a one-tailed Student's t-test at the 95% confidence level.

Gamma background levels for 1999 were determined by averaging the annual total measurement from the two background stations. The annual average result from these stations was 56.1 mrem/year (0.56 mSv/year) with a standard deviation of 2 mrem/year (0.02 mSv/year). This average background is within 10% of the NCRP 94 estimate of 55 mrem/year (0.55 mSv/year) (Ref. 15).

Table 4-5 1999 Environmental TLD Results[a]

LOCATION	1ST QUARTER (mrem)[b]	2ND QUARTER (mrem)[b]	3RD QUARTER (mrem)[b]	4TH QUARTER (mrem)[b]	ANNUAL TOTAL (mrem/yr)[b]	STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X)[c]
WELDON SPRING QUARRY							
TD-1002	12.8	12.8	14.6	14.4	54.6	0.98	
WELDON SPRING CHEMICAL PLANT AREA							
TD-2004	15.4	16.0	18.2	18.0	67.6	1.41	X
TD-2006	13.1	14.2	15.8	14.6	57.7	1.11	
TD-2025	14.4	12.1	16.6	17.2	60.3	2.32	
WELDON SPRING RAFFINATE PITS AREA							
TD-3001	14.2	13.7	15.6	15.0	58.5	0.84	
TD-3002	10.0	14.8	16.5	15.4	56.7	2.87	
TD-3003	19.2	17.5	18.6	17.6	72.9	0.82	X
TD-3004	12.8	13.1	16.6	15.8	58.3	1.91	
OFF SITE AREA							
TD-4001	13.3	12.3	14.8	14.3	54.7	1.11	
TD-4002	12.1	12.3	13.8	13.1	51.3	0.78	
TD-4003	11.2	10.4	12.8	12.2	46.6	1.06	
TD-4005*	13.1	12.5	15.5	15.4	56.5	1.55	
TD-4007	13.7	13.9	16.2	14.8	58.6	1.14	
TD-4009*	12.8	13.1	14.7	15.0	55.6	1.11	
TD-4013	13.7	13.8	16.5	17.1	61.1	1.78	

* Denotes background location.
(a) Results include natural background gamma radiation.
(b) To convert from mrem to mSv, divide by 100.
(c) Statistical significance is determined by comparing the total annual concentration for a monitoring location with the total annual background concentration, using a one-tailed Student's t-test at the 95% confidence level.

4.3.4 Data Analysis

Statistical analysis of TLD results revealed that, at the 95% confidence level, two stations had annual results greater than background levels. These stations were TD-2004, located along the northeastern perimeter of the chemical plant and TD-3003, located west of the TSA. Results

for all other stations were indistinguishable from background levels. As a comparison, four stations had annual results greater than background during 1998.

4.3.4.1 Chemical Plant/Raffinate Pits

The annual effective dose equivalent from external gamma radiation measured by TLDs at the chemical plant and raffinate pits ranged from 56.7 mrem (0.57 mSv) to 72.9 mrem (0.73 mSv). These results are lower than previous years for these areas due to the completion of remediation of most of the chemical plant area.

4.3.4.2 Quarry

The annual effective dose equivalent from external gamma radiation measured by TLDs at the quarry was 54.6 mrem (0.55 mSv). This result is comparable to previous years for this area.

4.3.4.3 Off-Site Locations

The annual effective dose equivalent from external gamma radiation measured by TLDs at off-site locations ranged from 46.6 mrem (0.47 mSv) to 61.1 mrem (0.61 mSv). Background concentrations ranged from 55.6 mrem (0.56 mSv) to 56.5 mrem (.57 mSv). These results are comparable to previous years for these areas.

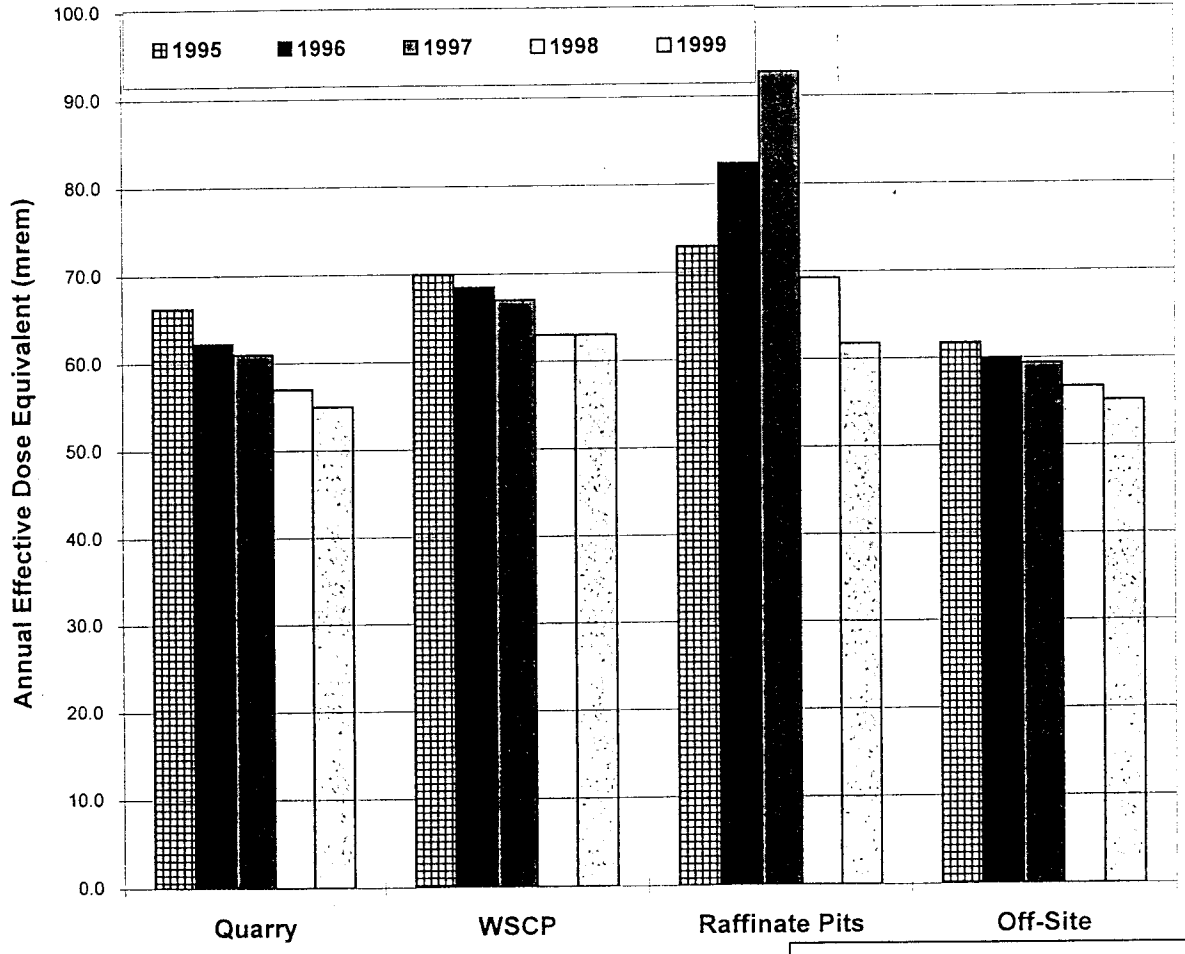
4.3.4.4 Five-Year Trend Analysis of TLDs

Gamma radiation exposure monitoring results for the last 5 years are depicted in Figure 4-7. The graph shows yearly monitoring result totals for the chemical plant, raffinate pits, quarry, and off-site locations. The results include the natural background dose rate. Results indicate a downward trend in measurements around the raffinate pits due to completion of most of the remediation work in this area. No other trends are evident.

4.4 Radioactive Air Particulate Monitoring

4.4.1 Program Overview

Radioactive air particulates are airborne dust particles that contain radioactive contaminants. Background concentrations of radioactive air particulates are affected by the soil concentrations of naturally occurring radionuclides, soil moisture content, meteorological conditions, and geological conditions. Many areas on site contain above background concentrations of soil contamination, which can result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the site can



ENVIRONMENTAL TLD
5-YEAR TRENDS

FIGURE 4-7

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result from wind erosion of contaminated soils piles or remedial work activities, such as moving equipment and vehicles in contaminated areas.

In 1999, the WSSRAP monitored radioactive air particulates weekly at 18 continuous permanent low volume air sampling stations: nine at the chemical plant perimeter, two at the quarry, and seven at off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 4-2, 4-3, and 4-4. Additional low volume air monitoring samplers may be deployed on a temporary basis when current activities warrant their use. The low volume samplers collect airborne particulates by drawing ambient air at a flow rate of approximately 40 l/min (1.4 cfm) through mixed cellulose ester filters with a 0.80-micron pore size. The filters are then counted using a gas flow proportional counter to determine the amount of long-lived gross alpha activity in the particulates present on the filter surface.

The WSSRAP also monitored specific airborne radionuclides (i.e., total uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232) as part of the NESHAPs program to demonstrate compliance with 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities*. Details of NESHAPs monitoring are in Section 6.

4.4.2 Applicable Standards

The Weldon Spring site is contaminated with a combination of alpha-emitting radionuclides, including isotopes of uranium, thorium, and their decay products. The gross alpha concentrations measured by the low-volume samplers thus include contributions from a wide array of alpha emitters. The DCGs for inhalation of the radionuclides found at the WSSRAP are listed in Chapter III of DOE Order 5400.5.

4.4.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 18 permanent low volume stations are summarized in Table 4-6. Annual averages were calculated using uncensored weekly air particulate analytical results. Uncensored data refers to all results, including those near or below the minimum detectable concentration (MDC). The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 26) requires the use of uncensored data to minimize any bias in arithmetic averages and standard deviation calculations. Annual results represent the average of up to 52 weeks of data for each monitoring station.

The typical MDC for low volume air particulate sampling at the WSSRAP is 2.0E-16 μCi/ml (7.4E-12 Bq/ml). This MDC is low enough to allow detection of Th-232, which has the lowest DCG at the site of 7.0E-15 μCi/ml (2.6E-10 Bq/ml). If an individual inhales airborne contaminants at the DCG for 1 year, the resulting committed effective dose equivalent is 100 mrem (1 mSv). Thus, this MDC allows the WSSRAP to demonstrate compliance with the DOE Order 5400.5 limit of 100 mrem (1 mSv).

Table 4-6 1999 Radioactive Air Particulate Gross Alpha Results

MONITORING STATION ID	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (xE-15 μCi/ml)[b][d]	STANDARD DEVIATION (xE-15 μCi/ml)	NUMBER OF SAMPLES/TOTAL NUMBER OF WEEKS	STATISTICALLY SIGNIFICANT (X)[C]
WELDON SPRING QUARRY				
AP-1009	1.33	0.389	52/52	
AP-1017	1.29	0.431	52/52	
WELDON SPRING CHEMICAL PLANT/RAFFINATE PIT PERIMETER				
AP-2001	1.43	0.482	52/52	
AP-2002	1.79	0.602	52/52	X
AP-2005	1.47	0.436	52/52	X
AP-2008	1.56	0.613	52/52	X
AP-2013	1.78	0.648	44/52	X
AP-2025	1.75	0.688	52/52	X
AP-3003	1.70	0.680	52/52	X
AP-3004	1.95	1.08	52/52	X
AP-3014	1.69	0.643	52/52	X
OFF-SITE				
AP-4006[e]	1.30	0.409	50/52	
AP-4007	1.33	0.383	49/52	
AP-4008	1.37	0.397	52/52	
AP-4011	1.31	0.383	52/52	
AP-4012[a]	1.30	0.418	52/52	
AP-4013	1.26	0.447	52/52	
AP-4014	1.38	0.472	45/52	

(a) Indicates background monitoring station. Background concentration is based on 52 weeks of data.
(b) The annual average gross alpha concentrations include background and were calculated using uncensored data, which includes results less than reported minimum detectable concentrations.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year (52-week) background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d) To convert from μCi/ml to Bq/ml, multiply by 37,000.
(e) Includes results from two co-located monitors.

4.4.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that eight monitoring stations were greater than the 52-week background concentrations. Station AP-4012 indicated an annual average background concentration of 1.30E-15 μCi/ml (4.81E-11 Bq/ml).

4.4.4.1 Chemical Plant/Raffinate Pits

The average annual concentrations at the chemical plant/raffinate pits perimeter ranged from 1.43E-15 μCi/ml (5.29E-11 Bq/ml) to 1.95E-15 μCi/ml (7.22E-11 Bq/ml). All monitoring stations except AP-2001 were statistically greater than the 52-week average background. The chemical plant and raffinate pits results are similar to those measured in 1998.

4.4.4.2 Quarry

The average concentrations at the quarry perimeter ranged from 1.29E-15 μCi/ml (4.77E-11 Bq/ml) to 1.33E-15 μCi/ml (4.92E-11 Bq/ml). These results are comparable to those measured during 1998.

4.4.4.3 Off-Site Locations

The average concentrations at off-site locations ranged from 1.26E-15 μCi/ml (4.66E-11 Bq/ml) to 1.38E-15 μCi/ml (5.11E-11 Bq/ml). All results are similar to those measured during previous years.

4.5 Airborne Asbestos Monitoring

Environmental monitoring for asbestos fibers was conducted during April-July 1999 at Francis Howell High School (AP-4006) and at the Weldon Spring site perimeter (AP-2001, AP-2002, AP-2005, AP-3004, and AP-2025). These locations are identified in Figures 4-1 and 4-3. Filters were collected weekly and shipped off-site biweekly for analysis.

Two methods are used to analyze asbestos samples. Phased contrast microscopy (PCM) indicates fibers that have the same general size and shape as asbestos; however, this method does not distinguish between asbestos and nonasbestos fibers. Transmission electron microscopy (TEM) measures actual asbestos fiber concentrations. If a PCM measurement indicates a concentration above the site environmental action level (0.01 fibers per milliliter of air), the sample is then reanalyzed by the off-site laboratory by the TEM method.

The results of environmental samples collected at Francis Howell High School and the site perimeter are provided in Table 4-7. A total of 55 PCM samples were collected with all

samples indicating results above the detection limits. The range of samples above the detection limit (generally 7 fibers/mm^2) was 0.0003 to 0.0096 fibers per milliliter of air (f/ml). Because all PCM results were less than the site environmental action level, no samples were resubmitted for TEM analysis. All results of the environmental air samples collected from the site perimeter and Francis Howell High School were below the fiber concentration limit of 0.01 f/ml. These results indicate that asbestos fibers were effectively contained during the year.

Table 4-7 Summary of Asbestos Air Monitoring Results

MONITORING LOCATION ID	NUMBER OF SAMPLES/SAMPLES ABOVE DETECTION LIMIT	RANGE (fiber/ml)	AVERAGE (fiber/ml)
AP-2001	2/2	0.0044-0.0096	0.0070
AP-2002	14/14	0.00099-0.0075	0.0042
AP-2005	12/12	0.00099-0.0087	0.0039
AP-2025	12/12	0.0013-0.0090	0.0039
AP-3004	2/2	0.0057-0.0058	0.0058
AP-4006	13/13	0.0011-0.0074	0.0046

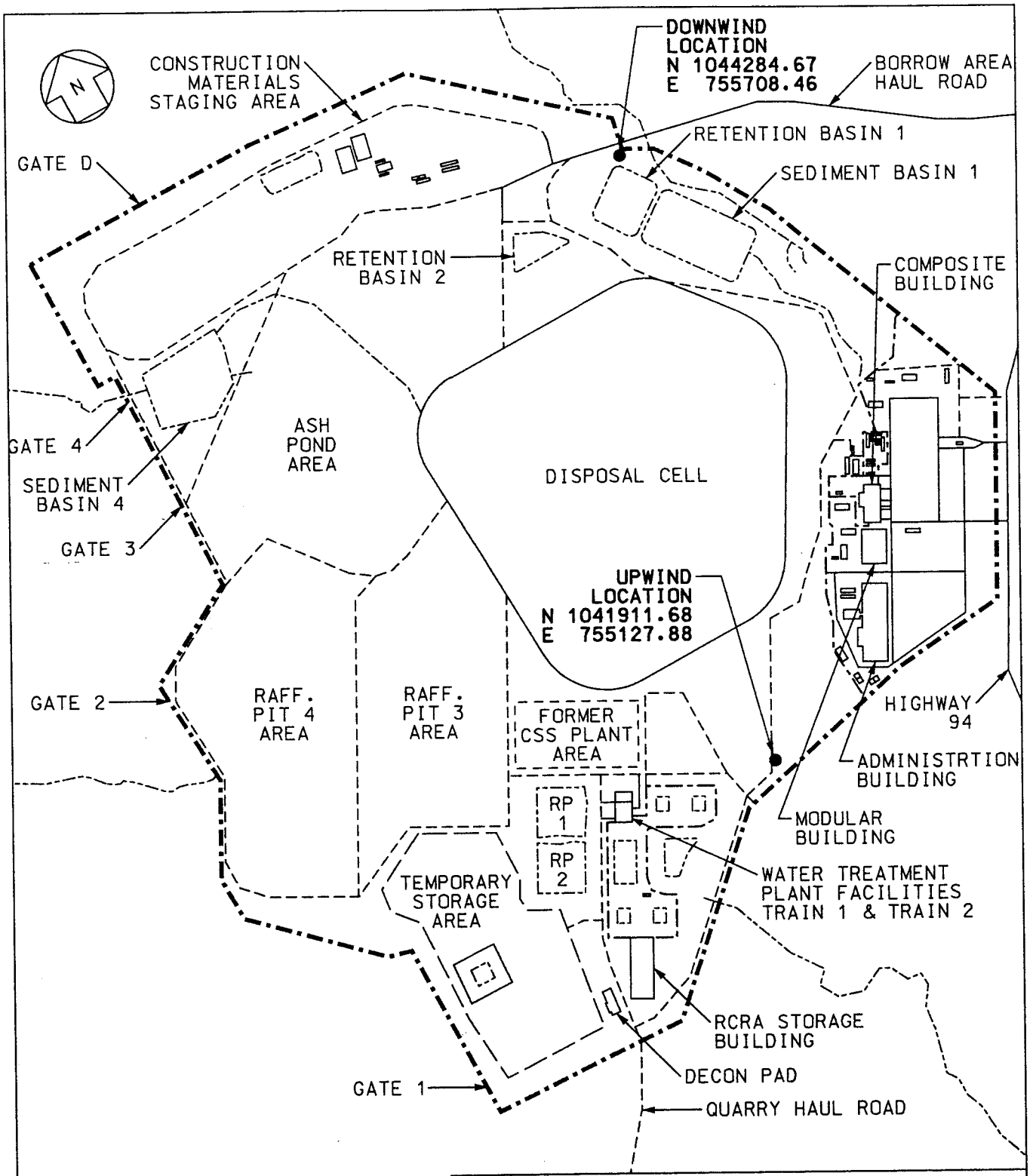
4.6 PM-10 Monitoring

4.6.1 Program Overview

PM-10 consists of airborne particulate matter (PM) with an aerodynamic equivalent diameter of less than 10 μm. It is often referred to as respirable dust because it is the fraction of total suspended particulate matter that can be entrained by the lungs upon inhalation, thus causing a potential health concern.

PM-10 is emitted during many different types of construction activities, such as:

- Pulverization or abrasion of surface materials by mechanical means (e.g., soil excavation or treatment).
- Loading or unloading of bulk dry material (e.g., transfer of fly ash from trucks to storage silos).
- Movement of turbulent air currents over exposed surfaces (e.g., wind erosion of stockpiles).
- Re-entrainment of road dust due to vehicle or heavy equipment traffic (e.g., soil hauling activities).



PLAN LAYOUT OF THE WELDON SPRING CHEMICAL PLANT SITE AND RAFFINATE PIT AREA

FIGURE 4-8

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- Combustion of fossil fuels (e.g., diesel-powered engines or generators).

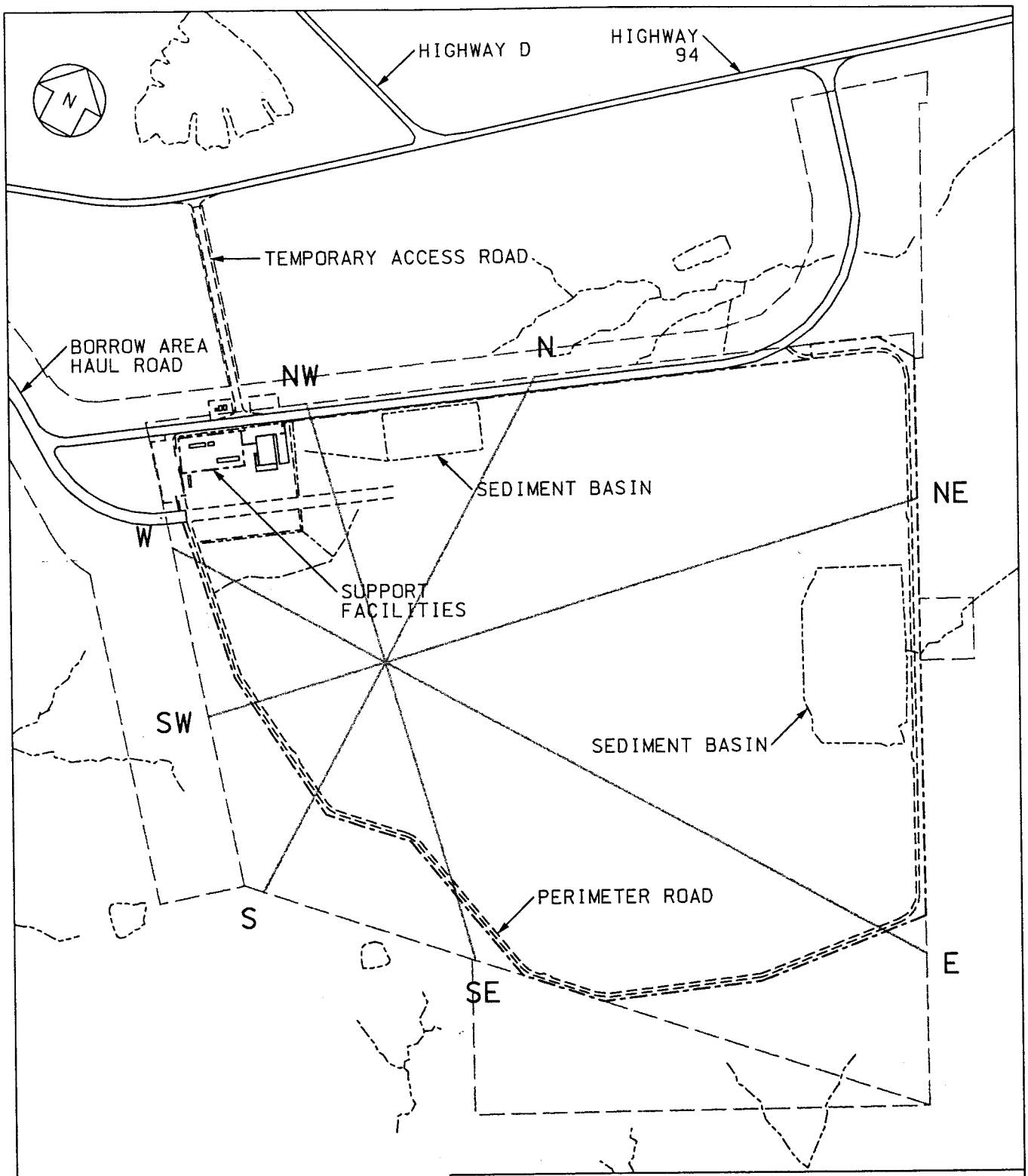
During 1999, the WSSRAP monitored ambient PM-10 levels at the perimeter of both the chemical plant area and the Borrow Area, and along the Borrow Area haul road. Portable monitoring stations, consisting of real-time aerosol monitors (RAMs) fitted with PM-10 impactor heads, were used to monitor upwind and downwind of work activities, concurrently. The chemical plant area map in Figure 4-8 shows the permanent locations established to monitor PM-10 emissions from disposal cell operations, based on historical prevailing wind patterns. Borrow Area locations were determined each monitoring period, based on the National Weather Service local 24-hour forecast. Figure 4-9 shows the 16 designated locations along the Borrow Area perimeter where monitors could be placed, depending on predicted wind directions for the monitoring period.

PM-10 monitoring was conducted weekly during the construction season (i.e., May to October) at both the chemical plant and Borrow Area perimeters. The chemical plant was also monitored weekly during November and December since there were construction activities taking place in and around the disposal cell. In addition, measurements were made along the haul road between the Borrow Area and the disposal cell. Occasionally, severe weather conditions such as high winds, below-freezing temperatures, or significant precipitation precluded the use of the monitoring equipment, and that monitoring period was skipped. Since this usually coincided with the curtailment of excavation and hauling activities, it is unlikely that any exceedences of the site action level would have occurred during these times.

4.6.2 Applicable Standards

PM-10 monitoring is conducted at the WSSRAP to assess the ambient effects of construction and remedial activities, as committed to in the *Record of Decision for Remedial Action at the Chemical Plant of the Weldon Spring Site* (ROD) (Ref. 9). The ROD states that although the National Ambient Air Quality Standards (NAAQS) "are not applicable and/or relevant and appropriate requirements (ARARs), the standards provide a sound technical basis for ensuring protection of public health and welfare during implementation and will be considered for components of the remedial action involving potential air releases" (pp. 55-56).

While not specifically subject to the PM-10 NAAQS, the WSSRAP instituted a voluntary PM-10 monitoring program in April 1998, based on the results of screening models and discussions with the Missouri Department of Natural Resources (MDNR). The program is designed to assess the effectiveness of dust control measures and provide a basis for modifying them as necessary during remedial activities. A site action level of 150 $\mu g/m^3$ has been established for 24-hour average concentrations of PM-10 at the WSSRAP perimeter. Any exceedences of this limit would trigger the actions outlined in Table 4 of Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting.*



PLAN LAYOUT OF THE WELDON SPRING BORROW AREA

FIGURE 4-9

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4.6.3 Monitoring Results

Data loggers attached to the RAMs recorded ambient PM-10 concentrations once per second. Hourly minimum, maximum, and average, as well as 15-minute STEL values were calculated and reported for each monitoring period. The resulting 24-hour average concentrations were all below the site action level of 150 $\mu g/m^3$. Table 4-8 shows the monthly average concentrations measured at the chemical plant, Borrow Area, and haul road.

Table 4-8 1999 PM-10 Data for the Weldon Spring Site Remedial Action Project

	NUMBER OF SAMPLING EVENTS	24-HR AVERAGE MEASURED CONCENTRATION ($\mu g/m^3$)	
	(UPWIND/DOWNWIND)	UPWIND	DOWNWIND
WSCP			
February	3/5	25	23
March	3/6	22	23
April	2/6	29	28
May	4/4	21	11
June	4/4	22	22
July	5/4	14	18
August	4/7	30	26
September	5/8	17	23
October	4/6	19	16
November	3/6	28	23
BORROW AREA			
March	4/8	19	30
April	1/2	23	23
May	3/4	8	9
June	3/4	11	9
July	4/4	25	26
August	5/10	23	13
September	4/6	9	18
October	3/5	6	9
November	3/6	14	18
HAUL ROAD			
May	1	19	N/A
June	1	4	N/A
July	0	No Data	N/A
August	1	15	N/A
September	0	No Data	N/A
October	2	9	N/A

N/A not applicable
ND No data recorded

The highest 24-hour average concentrations of PM-10 recorded at the chemical plant in 1999 were 67 $\mu g/m^3$ at the upwind site and 57 $\mu g/m^3$ at the downwind site. The highest 24-hour

average concentrations at the Borrow Area were 51 $\mu g/m^3$ at the upwind site and 97 $\mu g/m^3$ at the downwind site. The highest haul road concentration was 19 $\mu g/m^3$.

4.6.4 Data Analysis

Results of the 1999 PM-10 monitoring program demonstrate that remediation activities conducted at the WSSRAP have had no significant impact on ambient dust levels. Monitoring stations near the site perimeter have recorded minor fluctuations in PM-10, but all results have been substantially below the 150-$\mu g/m^3$ standard for 24-hour average concentration.

5. RADIATION DOSE ANALYSIS

This section evaluates the effects of atmospheric releases and surface and groundwater discharges of radiological contaminants from the Weldon Spring Site Remedial Action Project (WSSRAP). Potential annual dose equivalents to the general public have been calculated and are presented in this section. The calculations are compared to U.S. Department of Energy (DOE) limits contained in DOE Order 5400.5 to demonstrate compliance with regulatory requirements.

Dose calculations are presented in this section for a hypothetical maximally exposed individual and a collective population. The exposure conditions used in the dose calculations are further discussed in respective environmental monitoring sections of this report.

Dose calculations related to airborne emissions as required by 40 CFR 61, Subpart H *(National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities)* are presented in Section 6, National Emission Standards for Hazardous Air Pollutants (NESHAPS) Program.

5.1 Highlights

- The largest total effective dose equivalent (TEDE) to a maximally exposed individual from all pathways combined was 2.63 mrem (0.0263 mSv), estimated for an individual who works full-time at the Missouri Highway and Transportation Department (MHTD) maintenance facility. This value represents 2.63% of the DOE limit of 100 mrem (1 mSv) above background levels.

- The collective population effective dose equivalent (CPEDE) was estimated to be 0.18 person-rem (0.0018 person-Sv) for users of the Busch Memorial Conservation Area, and employees of the MHTD facility and WSSRAP offices.

5.2 Pathway Analysis

In developing specific elements of the WSSRAP environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are reviewed annually to determine which pathways are complete. This pathway analysis is detailed in the site *Environmental Monitoring Plan* (Ref. 8). As required by DOE Order 5400.1, evaluation of each exposure pathway is based on the sources, release mechanisms, types, and probable environmental fates of contaminants, and the locations and activities of potential receptors. Pathways are reviewed to determine whether a link exists between one or more contaminant sources, or between one or more environmental transport processes, to an exposure point where human or ecological receptors are present. If it is determined that a link exists, the pathway is termed "complete." Complete pathways are used to assess radiological and nonradiological exposures. Each complete pathway is reviewed to determine whether a potential

for exposure was present during the time period of concern. If this is the case, the pathway is termed "applicable." Only applicable pathways are considered in estimates of dose.

Table 5-1 lists the six complete pathways for exposure to radiological contaminants evaluated under the WSSRAP environmental monitoring program. These pathways are used to evaluate monitoring requirements and to determine radiological exposures from the site. Of the six complete pathways, five were applicable in 1999 and were thus incorporated into radiological dose estimates. These are Liquid (B), Liquid (C), Airborne (A), Airborne (B), and External. Assessments of potential exposure routes in the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 27) have shown that the dose potential for pathways not listed in Table 5-1 is miniscule.

Table 5-1 Complete Radiological Exposure Pathways for the Weldon Spring Site

EXPOSURE PATHWAY	PATHWAY DESCRIPTION	APPLICABLE TO 1999 DOSE ESTIMATE
Liquid(A)	Ingestion of groundwater from local wells downgradient from the site.	N
Liquid(B)	Ingestion of game and fish inhabiting wildlife area.	Y
Liquid(C)	Ingestion of surface water and sediments.	Y
Airborne(A)	Inhalation of particulates dispersed through wind erosion and remedial activities.	Y
Airborne(B)	Inhalation of radon and radon decay products emitted from contaminated soils/wastes.	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y

As shown in Table 5-1, the Liquid (A) pathway is not applicable to the 1999 dose estimate for the WSSRAP. Concentrations of radioactive contaminants in the production wells near the Weldon Spring Quarry are currently comparable to background concentrations (see Section 8.5). In addition, no drinking water wells are located in the vicinity of the chemical plant and raffinate pits area.

The applicable radiological public dose guidelines for the WSSRAP are as follows:

- NESHAPs standard of 10 mrem (0.10 mSv) effective dose equivalent annually due to airborne emissions other than radon at off-site receptor locations.

- DOE limit of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis (excluding background).

5.3 Radiological Release Estimates

Estimates of radiological releases to air and surface water were calculated for radioactive particulates. Table 5-2 shows the estimated activity release of radionuclides to the environment, the corresponding mass released, and the half-life for each radionuclide present at the Weldon Spring site.

5.3.1 Airborne Radiological Releases

The airborne radiological release estimates shown in Table 5-2 were calculated based on site characterization data and low volume monitoring results at eight stations located at the chemical plant perimeter. A series of box models was used to predict the airborne particulate release rate from the chemical plant. The assumptions used in estimating airborne releases are shown in Appendix B.

5.3.2 Waterborne Radiological Releases

During 1999, intermittent surface water runoff transported isotopes of uranium, thorium, and radium from the site through six major discharge routes. These include two water treatment plant outfalls and four storm water outfalls (see Section 7). These outfalls were monitored monthly in accordance with National Pollutant Discharge Elimination System (NPDES) requirements. Natural uranium concentrations measured in runoff water were multiplied by the natural uranium activity ratios for U-234, U-235, and U-238 (49.1%, 2.3%, and 48.6%, respectively) to determine the waterborne releases of those isotopes. (All release estimates are based on data in Tables 7-3 and 7-5). Results are listed in Table 5-2.

5.4 Exposure Scenarios

Dose calculations were performed for maximally exposed individuals, collective population, and critical receptor locations for applicable exposure pathways (see Table 5-1) to assess dose due to radiological releases from the Weldon Spring site. First, conditions were set

Table 5-2 Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
U-238	5.15E-6	1.90E-3	5.69E3	4.47E9
U-235	2.09E-7	9.0E-5	41.4	7.04E8
U-234	5.15E-6	1.90E-3	0.3	2.46E5
Ra-226	--	3.59E-5	3.59E-5	1,600

Table 5-2 Radionuclide Emissions to the Environment (Continued)

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
Ra-228	--	3.31E-5	1.22E-7	5.76
Th-230	4.73E-5	1.13E-4	7.78E-3	7.54E4
Th-228	5.57E-6	1.52E-5	2.53E-8	1.91
Th-232	6.26E-6	1.73E-5	216	1.40E10
Total Activity	6.96E-5	4.10E-3	5.95E-3	N/A

N/A Not applicable.
-- Not distinguishable from background at perimeter monitoring locations.
Multiply by 3.7E10 to convert Ci to Bq.

to determine the total effective dose equivalent to a maximally exposed individual at each of the main site areas: the chemical plant and raffinate pits area, the quarry, and vicinity properties. A second dose equivalent for a collective population was calculated. A third set of dose equivalent calculations was performed to meet NESHAPs requirements (see Section 6).

Calculations using perimeter and off-site monitoring data determined the collective population dose equivalent to be approximately 0.18 person-rem per year (0.0018 person-Sv) from all pathways combined. Since all air monitoring stations (other than the background station) are within a 13 km (8.1 mi) radius of the site, and all measurements recorded within this radius result in TEDEs that are well below NESHAPs and DOE limits, incorporating a dose calculation for a population within 80 km (49.6 mi) of the site is unnecessary. Rather, the collective population dose equivalent was calculated for specific target populations where complete exposure pathways were determined to exist.

The scenarios and models used to evaluate these radiological exposures are conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods prescribed here. Estimates of health risks are based on statistical models using epidemiological data collected from large groups of people exposed to radiation under various circumstances; therefore, they are not applicable to single individuals. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case for the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 5-3. In addition, the percentage of the DOE limit of 100 mrem (1.0 mSv) TEDE is provided.

The collective population dose equivalent estimate, provided in units of person-rem (person-Sv), is the product of the effective dose equivalent estimate at an exposure point and the number of persons potentially exposed. For the WSSRAP, exposure points are locations where

members of the public are potentially exposed to above-background levels of airborne radioactive particulates, radon gas, external gamma radiation, or above-background radionuclide concentrations in water or food. The committed effective dose equivalent is calculated by measuring radionuclide concentrations in the air, water, and food at a given exposure point and applying standard breathing rates, ingestion rates, and dose equivalent conversion factors. These concentrations and reasonable exposure scenarios are used to estimate the amount of radioactivity ingested or inhaled by the potentially exposed population. The contribution from exposure to external gamma radiation is then factored into the collective population effective dose equivalent.

All ingestion calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 (Ref. 28) and 30 (Ref. 29) for a 50-year committed effective dose equivalent (CEDE). Dose conversion factors were obtained from the EPA *Federal Guidance Report No. 11* (Ref. 30).

5.5 Dose Equivalent Estimates

Dose equivalent estimates for the exposure scenarios were calculated using 1999 environmental monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose equivalent estimates are well below the standards set by the DOE for annual public exposure and U.S. Environmental Protection Agency (EPA) NESHAPs limits.

The 1999 TEDEs for hypothetical maximally exposed individuals near the chemical plant/raffinate pits and vicinity properties are 2.63 mrem (0.0263 mSv) and 0.31 mrem (3.1 μSv), respectively. These values represent less than 3% of the DOE standard of 100 mrem (1 mSv) above background for all exposure pathways. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem (3 mSv) (Ref. 65, Table 9.7). The collective population effective dose equivalent is 0.18 person-rem (0.0018 person-Sv) for recreational users of the Busch Memorial Conservation Area and employees of the Missouri Highway and Transportation Department facility and WSSRAP offices. Assumptions upon which these doses are based are detailed in the following sections.

5.5.1 Radiation Dose Equivalent From the Chemical Plant and Raffinate Pits to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the chemical plant and raffinate pits and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent assume a realistic residence time that is less than 100%. A full-time employee at the MHTD maintenance facility remediation project was considered to be the maximally exposed individual to releases of radionuclides from the chemical plant area.

Table 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INTAKE RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (mrem)	PERCENT OF DOE LIMIT
WSCP/WSRP Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Working at MHTD facility	Direct Exposure	2,000 hr	11.5 mrem/yr	N/A	2.63	2.63%
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--
WSQ Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	--	--	--	--	--	--	--
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--
WSVP Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	Drinking water from Burgermeister Spring	Water	N/A	0.237 l/week	See Appendix B for list of radionuclide concentrations	0.31	0.31%
	External	--	--	--	--	--	--	--
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--

Table 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INTAKE RATE	CONCENTRATION	COLLECTIVE POPULATION DOSE EQUIVALENT (person-rem)	PERCENT OF DOE LIMIT
Collective Population	Liquid(B)	Ingestion of fish from Busch Lake 35 (population = 100,000)	Fish	N/A	0.55 g/day	0.019 pCi/g	0.103	N/A
	Liquid(C)	Swimming at Busch Lake 35 (population = 7,480)	Water	0.285 hr/person	0.05 liters/hour	10.7 pCi/l	0.0003	N/A
	External	Working at MHTD Facility (9 persons)	Direct Exposure	2,000 hours	11.5 mrem/year	N/A	0.024	N/A
	Airborne(A)	Working at WSSRAP Administration Building (160 persons)	Air	2,500 hours	1.2 m^3/hr[(a)]	2.6E-16 µCi/ml	0.052	N/A
	Airborne(B)	--	--	--	--	--	--	--

N/A Scenario is not applicable to the hypothetical individual.
-- Scenario not formulated because results were indistinguishable from background.
WSCP Weldon Spring Chemical Plant.
WSRP Weldon Spring raffinate pits.
WSQ Weldon Spring Quarry.
WSVP Weldon Spring vicinity properties.
MHTD Missouri Highway and Transportation Department maintenance facility
Multiply by 0.037 to convert pCi to Bq.
Multiply by 0.01 to convert mrem to mSv.
Multiply by 0.01 to convert person-rem to person-Sv.
(a) A breathing rate of 1.2 m^3/hour is used for an adult male engaged in light activity (Ref. 25).

The low volume sampler and radon detectors near the MHTD facility indicated no greater than background concentrations of airborne radioactive particulates and thoron gas. However, the annual environmental TLD result (Station TD-2004) exceeded background levels for the year; therefore, a dose estimate was calculated based on this measurement.

The exposure scenario assumptions are as follows:

- External exposure occurs to the maximally exposed individual while working at the MHTD near the Weldon Spring Chemical Plant perimeter for a total of 2,000 hours per year.

- Net annual gamma exposure rate of 11.5 mrem/year (for continuous exposure), measured at TD-2004 at the northeastern boundary of the chemical plant. For 1999, continuous exposure time is 8,760 hours.

Based on the exposure scenario and assumptions described above, a maximally exposed individual working 2,000 hours/year at the MHTD facility received a total effective dose equivalent of 2.63 mrem (0.0263 mSv) from external exposure.

5.5.2 Radiation Dose From the Weldon Spring Quarry to a Hypothetical Maximally Exposed Individual

Because all monitoring results at the quarry were indistinguishable from background levels during 1999, no dose estimate is necessary for a maximally exposed individual at the quarry.

5.5.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent the Burgermeister Spring area of the Busch Memorial Conservation Area. This scenario provides a conservative but plausible exposure assessment. No private residences are adjacent to Burgermeister Spring (it is situated on land currently managed by the Missouri Department of Conservation [MDC]). Therefore, the calculation of dose equivalent due to the applicable pathway of water ingestion (Liquid C) assumes a realistic occupancy time of one day per week. This scenario is based on a hypothetical individual who drank from Burgermeister Spring on a weekly basis in 1999.

Exposure scenario assumptions particular to this dose calculation include the following:

- Annual average radioactive particulate concentrations at the Busch Memorial Conservation Area were indistinguishable from background; therefore, no

inhalation dose due to radioactive air particulates was calculated for an individual at Burgermeister Spring.

- No contribution to the estimated dose was included from radon or radon progeny concentrations associated with the Airborne (B) pathway, because annual alpha-track results in the area were at background levels.

- No contribution to the estimated dose was included for the external pathway, because environmental TLD results at the Busch Memorial Conservation Area indicated no greater than background levels.

- Maximum radionuclide concentrations in water samples taken from Burgermeister Spring during 1999 (see Appendix B) were assumed to be present in the water ingested by the maximally exposed individual.

- Dose equivalent conversion factors for ingestion, as follows: total soluble uranium, 2.69E-4 mrem/pCi; Ra-226, 1.33E-3 mrem/pCi; Ra-228, 1.44E-3 mrem/pCi; Th-228, 3.96E-4 mrem/pCi; Th-230, 5.48E-4 mrem/pCi; Th-232, 2.73E-3 mrem/pCi; Ra-224, 3.66E-4 mrem/pCi; and Pb-212, 4.56E-5 mrem/pCi (Ref. 30).

The estimated total effective dose equivalent to the maximally exposed individual at the vicinity properties due to consumption of water from Burgermeister Spring was 0.31 mrem (3.1 μSv).

5.5.4 Collective Population Dose

This section discusses the estimated CPEDE to the populations assumed to be exposed to radioactive emissions from the WSSRAP. Of the eight perimeter monitoring stations that exceeded background levels for radioactive particulates, the locations likely to be frequented by members of the public are AP-2005 and AP-2008. These stations are located near the WSSRAP offices.

Measurements made using environmental thermoluminescent dosimeters (TLDs) indicated above background results for gamma exposure at the MHTD facility, necessitating the development of general population direct exposure scenarios for these locations.

Another potential general population exposure is from the consumption of water, sediment, and fish from the August A. Busch Memorial Conservation Area. Two lakes at the conservation area receive runoff from the Weldon Spring site and are used for fishing and boating. The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing, boating, and swimming activities. Only the ingestion pathways Liquid (B) and

Liquid (C) were considered plausible for this assessment. Exposure scenario assumptions particular to this dose calculation are as follows:

- It is estimated that there are approximately 200,000 fishing visits per year at the Busch Memorial Conservation Area (Ref. 31), which is adjacent to the chemical plant and raffinate pits area. In addition, approximately 7,480 persons per year participate in recreational boating activities. Busch Lakes 34, 35, and 36 receive runoff from the chemical plant and raffinate pits area, and both lakes are used for fishing and boating.

- The ratio of fish caught to time spent is 0.4 fish/hour, and the ratio of fish kept to fish caught is 0.5. The average duration of each visit is assumed to be 2.5 hours. If each fish caught is consumed by a different person, the affected population would be 100,000 persons.

- The highest average total uranium concentration in a composite sunfish sample collected from Lake 35 in 1998 (the last year for which data are available) was 0.019 pCi/g (5.1E-4 Bq/g).

- The average time spent at the Busch Conservation Area per boating trip was approximately 5.7 hours (Ref. 31).

- Each of 7,480 boaters made only one visit to the area and spent 5% of the time swimming.

- The maximum water concentration of total uranium was 10.7 pCi/l (0.29 Bq/l) (see Table 7-12).

- No contribution from airborne pathways was included in the Busch Memorial Conservation Area dose estimates. Results from the measurements near the lakes indicated that there was no reason to suspect, at the 95% confidence level, that concentrations of airborne radioactive particulates or Rn-222 or Rn-220 gas were greater than background levels.

For 1999, the estimated population effective dose equivalent for the Busch lakes scenario was 0.103 person-rem (1.03E-3 person-Sv).

The scenario used for the MHTD facility is the same as that listed in Section 5.5.1. Assuming nine individuals worked full-time (i.e., 2,000 hours) at the facility in 1999, the collective population effective dose equivalent for the MHTD facility is 0.024 person-rem (0.00024 person-Sv).

The scenario for the WSSRAP offices includes only inhalation of above-background concentrations of radionuclides as measured by low volume monitoring Station AP-2008 in 1999. The population at the WSSRAP offices includes approximately 160 employees who work an estimated 2,500 hours/year. Based on an annual net gross alpha concentration of 2.6E-16 μCi/ml (9.62E-12 Bq/ml), and assuming that the source is the disposal cell, the collective population effective dose equivalent for employees at the WSSRAP offices is 0.052 person-rem (0.00052 person-Sv).

The estimated total collective population effective dose equivalent from all three scenarios combined is 0.18 person-rem (0.0018 person-Sv) for 1999. Calculations are presented in Appendix B, Section D.

6. NESHAPS PROGRAM

This section provides information on 1999 annual atmospheric emissions of radionuclides, in accordance with the requirements of 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*. Evaluations presented here include airborne emissions data and dose assessment and compliance information related to sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP).

6.1 NESHAPs Monitoring and Dose Assessment Highlights

- Results of National Emission Standards for Hazardous Air Pollutants (NESHAP) monitoring at the seven critical receptor monitoring locations indicated that no member of the public received greater than the effective dose equivalent limit of 10 mrem/yr.

- The highest dose assessment was for a maximally exposed individual residing continuously at the Busch Memorial Conservation Area. Results indicated an annual committed effective dose equivalent (CEDE) of 0.33 mrem (0.003 mSv) for 1999.

6.2 Source Description

The Weldon Spring site is being remediated in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *National Environmental Policy Act* (NEPA). The Weldon Spring Feed Materials Plant no longer operates as a uranium and thorium processing plant and was placed in mothball status in 1966. Therefore, radionuclides are no longer emitted from the original uranium processing plant sources (i.e., stacks, vents, or pipes described in 40 CFR 61, Subpart H).

Specific remedial activities at the site that may have contributed to airborne emissions of radionuclides in 1999 include the following:

- Excavation and hauling of contaminated soils from various locations around the site.

- In situ treatment and excavation of contaminated sludge in Raffinate Pits 1 and 2.

- Treatment and hauling of contaminated brine from the site water treatment plant.

- Placement of contaminated waste materials in the permanent on-site disposal cell.

- Operation of the site and quarry water treatment plants.

- Demolition of the chemical stabilization/solidification (CSS) plant.

Radiological and chemical contaminants (i.e., PCBs, nitroaromatic compounds, and metals) have been found in soil from several areas around the site. Most of the 88 ha (217 acres) of the chemical plant area soil had above background concentrations of uranium (>1 pCi/g) prior to remediation. Radionuclide concentrations in these soils ranged as shown in Table 6-1 (Ref. 2). Much of this material was excavated and hauled to the disposal cell in 1999.

Table 6-1 Contamination Levels in Site Soils and Raffinate Pit Sludge

	SITE SOIL CONCENTRATIONS (pCi/g)		RAFFINATE PIT SLUDGE CONCENTRATIONS (pCi/g)	
CONTAMINANT	MIN	MAX	MIN	MAX
U-238	0.3	2,259	N/A	N/A
Total Uranium	N/A	N/A	<10	3,400
Ra-226	0.2	452	<1	1,700
Ra-228	0.1	155	<4	1,400
Th-228	N/A	N/A	<3	1,100
Th-230	0.3	123	<8	34,000
Th-232	N/A	N/A	<4	1,400

N/A Not applicable

The raffinate pits were radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals. Radionuclide concentrations found in raffinate pit sludge ranged as shown in Table 6-1 (Ref. 33). In 1999, contaminated sludge was treated in situ and excavated from Raffinate Pits 1 and 2.

6.3 Air Emission Data

Most airborne emissions of radionuclides at the Weldon Spring site are diffuse in nature, and result from wind dispersion of surface soils, re-entrainment of dust and dirt from temporary waste storage areas, and generation of fugitive dust during remedial actions. The site and quarry water treatment plants constitute potential point sources of radionuclide emissions other than radon. On-site point sources that have the potential to emit radioactive airborne particulates are filtered using high efficiency particulate air (HEPA) exhaust systems.

Traditional methods of estimating airborne emissions of radionuclides have been used at the WSSRAP to support engineering design studies. These methods involve identification of the various industrial activities, characterization of the activities by assuming numerous process parameters (e.g., soil characteristics, vehicle characteristics, meteorological conditions, etc.), and application of empirically-derived emission factors. While this process has been useful for evaluating the need for emissions control during planned construction and remedial activities, the high degree of uncertainty associated with the resulting emissions estimates precludes its use in

obtaining an accurate assessment of effective dose equivalents to maximally exposed members of the public.

The WSSRAP uses an alternate method of tracking emissions from the site, as allowed by 40 CFR 61, Subpart H and approved by U.S. Environmental Protection Agency (EPA) Region VII (see Appendix A). A network of critical receptor monitors has been established to measure airborne radionuclide concentrations at locations where members of the public have the potential to be impacted by emissions from remedial activities at the site. Background concentrations are also measured so that the net contribution of emissions from remedial activities, and the resulting effective dose equivalents, can be determined. Details of this monitoring program are presented in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 20).

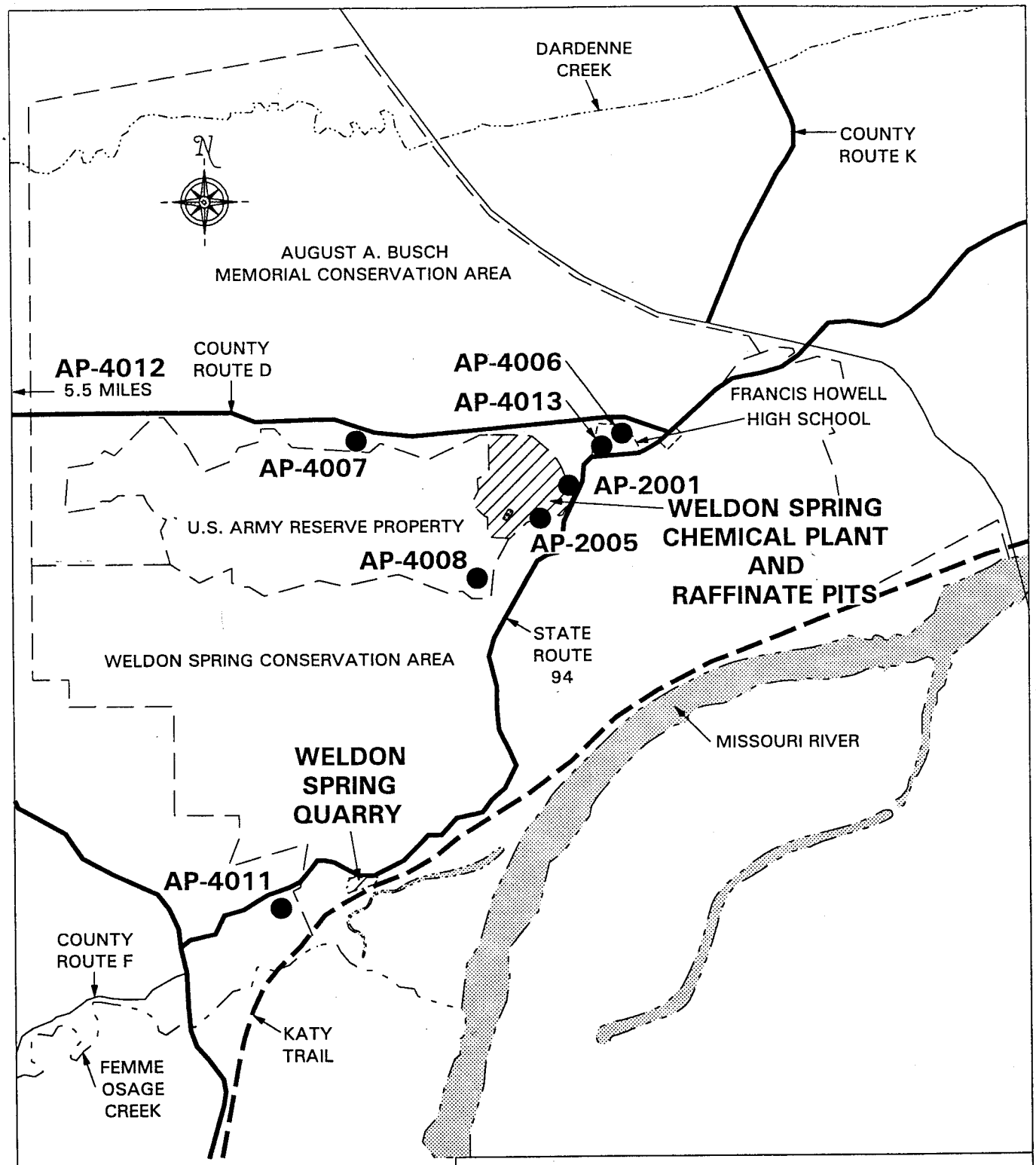
The design of the critical receptor network is summarized in Table 6-2. Locations of the monitors are shown on Figure 6-2.

Table 6-2 Design of Critical Receptor Monitoring Network

STATION ID	LOCATION
AP-2001	Highway Maintenance Facility
AP-2005	WSSRAP Administration Building
AP-4006	Francis Howell High School
AP-4007	Busch Memorial Conservation Area
AP-4008	Army Reserve Training Area
AP-4011	Nearest Quarry Residence
AP-4012 (background)	Daniel Boone Elementary School
AP-4013	Francis Howell High School Annex

6.3.1 Point Sources

Table 6-3 summarizes airborne effluent control at the chemical plant water treatment plant and the quarry water treatment plant, along with the nearest receptor locations. Because critical receptor monitoring is performed at the WSSRAP, no source-specific effluent monitoring is required by either 40 CFR 61 Subpart H or U.S. Department of Energy (DOE) Order 5400.5. Engineering calculations have been performed to estimate releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results predict an effective dose equivalent of less than 0.1 mrem (0.001 mSv) at the nearest receptor location.



NESHAPS CRITICAL RECEPTOR MONITORING LOCATIONS

FIGURE 6-1

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/001/0195		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	5/11/00

Table 6-3 WSSRAP Point Sources of Airborne Radionuclides

	EFFLUENT CONTROL		NEAREST RECEPTOR	
POINT SOURCE ID	DESCRIPTION	EFFICIENCY	DESCRIPTION	DISTANCE
Site Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP*	Administration Building	400 m
Quarry Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP*	Residence	700 m

* DOP – Dioctylphthalate

6.3.2 Grouped Sources

The WSSRAP has not defined any grouped sources.

6.3.3 Non-Point Sources

The primary sources of airborne emissions at the WSSRAP are diffuse sources in two general geographic areas: the chemical plant area and the quarry area. The characteristics of these sources and the potential for airborne emissions are discussed below.

The quarry diffuse source is a 3.6 ha (9 acre) limestone quarry located approximately 6.4 km (4 mi) south-southwest of the chemical plant area. The quarry is essentially in a closed basin; surface water within the rim flows to the quarry floor and into a pond that covers approximately 0.07 ha (0.2 acre). Historically, the quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) process wastes; uranium, radium, and thorium residues; the associated decay products from on-site and off-site processing of uranium and thorium; and building rubble and soils from the demolition of a uranium processing facility in St. Louis, Missouri. A major remediation project involving the removal and controlled temporary storage of approximately 110,000 m^3 (144,000 cu yd) of contaminated bulk waste was started in 1993 and completed at the end of 1995. Residual radioactive contamination remains at the quarry and could be a potential source of airborne particulates.

The Weldon Spring Chemical Plant diffuse source encompasses 91 ha (226 acres) on which the Ash Pond storage area (APSA), four raffinate pits, the temporary storage area (TSA), the material staging area (MSA), and the disposal cell are or were located. Airborne emissions from the chemical plant area occur during mechanical operations such as soil excavation and hauling, transfer of waste material to the permanent on-site disposal cell, and treatment and mixing of contaminated materials at the TSA and raffinate pits. Emissions may also result from windblown resuspension of radioactive particulates from site soils. More than 80% of the chemical plant area was confirmed clean by the end of 1999, thus significantly reducing the

exposed surface area with the potential to contribute to diffuse emissions of radioactive particulate.

The emission control strategy for all the above activities was to minimize the quantity of fine grain soil that was to be relocated, select equipment that would minimize dust generated during operations, limit surface exposure of contaminated soils, minimize hauling distances, and use water sprays to suppress dust.

6.4 Dose Assessment

The net measured concentrations of radionuclides at each critical receptor location are used to assess the annual committed effective dose equivalent (CEDE) to members of the public. The exposure scenarios listed in Table 6-4 represent the maximum expected exposure of any single individual working, residing, or visiting near each critical receptor location. Annual CEDEs have been calculated for each exposure scenario and are summarized in Table 6-4.

The rest of this section provides further details of the critical receptor monitoring network, and how it is used to estimate CEDEs and demonstrate compliance with the NESHAPs requirements.

6.4.1 Sampling Procedure

The seven designated critical receptor locations surrounding the Weldon Spring site have been selected based on their proximity to the site (less than 1 km [0.62 mi]) and the probability that members of the public would spend at least 8 hours per day near them. The seven critical receptor locations and the background monitoring location are shown in Figure 6-1. They include: the common boundary of the Weldon Spring Chemical Plant and the Missouri Highway and Transportation Department maintenance facility (AP-2001); the WSSRAP administration building (AP-2005); Francis Howell High School (AP-4006); the August A. Busch Memorial Conservation Area (AP-4007); the Weldon Spring Army Reserve Training Area on the Department of the Army property (AP-4008); 150 m (0.1 mi) from the residence nearest to the quarry (AP-4011), and the Francis Howell High School Annex (AP-4013). Daniel Boone Elementary School in New Melle, Missouri, is the designated background monitoring location (AP-4012). Technically, the WSSRAP administration building is considered an on-site receptor rather than a critical receptor because its occupants are not members of the general public, and the area is under DOE control. However, for reporting purposes, it is referred to as a critical receptor.

Each critical receptor location includes a low volume air particulate sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples are collected on mixed cellulose ester membrane filters approximately 1.5 m (5 ft) above the ground, and are exchanged and analyzed for gross alpha activity on a weekly basis. High volume samples are collected on large 20 cm x 25 cm (8 in. x 10 in.) glass fiber filters approximately 1.2 m (4 ft) above the

Table 6-4 Exposure Scenarios and NESHAPs Dose Estimates for 1999

STATION ID	LOCATION OF MONITOR	EXPOSURE SCENARIO			COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem/person)
		DESCRIPTION	NUMBER OF PERSONS	DURATION (hr/yr)	
AP-2001	Highway Maintenance Facility	Employee	9	2,000	0.0666 ± 0.0003
AP-2005	WSSRAP Administration Building	Employee	160	2,500	0.0673 ±0.1618
AP-4006	Francis Howell High School	Faculty or Student	1,600	1,620	0.0296 ± 0.0942
AP-4006	Francis Howell High School	Staff Members	7	2,250	0.0412 ± 0.1309
AP-4007	Busch Memorial Conservation Area	Employee	45	2,000	0.0753 ± 0.1856
AP-4007	Busch Memorial Conservation Area	Resident	3	8,760	0.3296 ± 0.8129
AP-4007	Busch Memorial Conservation Area	Visitor	450,000	2	0.0001 ± 0.0002
AP-4008	Army Reserve Training Area	Employee	2	1,280	0.0221 ± 0.0877
AP-4011	Nearest Quarry Residence	Resident	3	8,760	0.1454 ± 0.5701
AP-4013	Francis Howell High School Annex	Employee	53	2,000	0.5296 ± 0.1157[(a)]

NOTE: 1 mrem/person = 0.01 Sv/person

(a) The CEDE for AP-4013 is based on analytical data received from the laboratory, although this most likely overestimates the actual dose received at this critical receptor location (see Section 6.4.2 for discussion).

ground, and are also exchanged weekly but composited and analyzed quarterly for isotopic radionuclides. It is the high volume sampling results that are used to demonstrate NESHAPs compliance at the WSSRAP.

At the beginning of each calendar quarter, the high volume filters collected over the previous quarter are composited to form eight distinct samples, one for each critical receptor location and background station. The samples are analyzed for isotopic thorium, total uranium, Ra-226, and Ra-228. Background concentrations (i.e., those measured at AP-4012) are subtracted from the results for each critical receptor location to obtain net measured concentrations.

6.4.2 Net Measured Radionuclide Concentrations

Net measured radionuclide concentrations are listed in Table 6-5. These values are based on the quarterly sample analysis results obtained at each critical receptor location. All results are within historical ranges except the fourth quarter total uranium concentration reported for AP-4013, which is at least an order of magnitude higher than any previously reported concentration at any location in the critical receptor network.

An investigation was conducted to determine whether the elevated total uranium values reported for AP-4013 were a result of remediation activities at the WSSRAP or a non-valid result due to sample contamination or analytical error. The investigation involved the following activities:

- Validation of the analytical data.
- Reanalysis of the digested sample.
- Isotopic uranium analysis of the digested sample from AP-4013, two other critical receptors, and one of the spiked samples.
- Radiological survey of the monitoring station and immediate area.
- Detailed discussions with the laboratory regarding any potential contamination issues.
- Isotopic uranium analysis of the low volume filters collected at AP-4013 during the fourth quarter.

The results of the investigation indicated that the high level of uranium in the AP-4013 sample was present in isotopic activity ratios typically associated with depleted uranium, rather than natural uranium. (Depleted uranium is the form of uranium that is used by analytical laboratories as a quality control standard, whereas natural uranium is the form that would be

present in any airborne releases from the WSSRAP.) In addition, isotopic analysis of the low volume filters indicated no defensible uranium data above the minimum detectable activity.

There is strong evidence that the fourth quarter high volume uranium data are the result of artificial contamination most likely introduced during sample digestion at the laboratory. However, the values have been retained for reporting purposes, even though they are probably not representative of actual conditions at the Francis Howell High School Annex.

Annual average net concentrations of radionuclides are listed in Table 6-5 for each critical receptor. The limiting levels prescribed in 40 CFR 61, Subpart H, Appendix E, Table 2, are also listed for each radionuclide. The NESHAP requires that there be no exceedences of the limiting levels for net concentration of each radionuclide, and that the sum of the fractions obtained by dividing the annual net concentration of each radionuclide by its limiting level be less than one. Both of these requirements were met during 1999 even when the elevated uranium results collected at AP-4013 during the fourth quarter are included.

6.4.3 Dose Estimates

The net measured concentrations of radionuclides are combined with the maximum exposure scenario at each critical receptor location to estimate committed effective dose equivalents (CEDEs) according to the following formula:

$$CEDE\ (mrem) = Concentration\ (\mu Ci/m^3) \times DCF\ (mrem/\mu Ci) \times Exposure\ Duration\ (hr/yr) \times Breathing\ rate\ (m^3/hr)$$

where:

- Concentration is the net airborne concentration measured for a specific radionuclide at a specific monitoring station.
- DCF is the 50-year radioisotopic dose conversion factor listed for the inhalation exposure pathway in EPA's *Federal Guidance Report No. 11* (Ref. 30).
- Exposure duration represents the maximum time an individual is expected to be in the vicinity of a particular critical receptor.
- Breathing rate of 1.2 m^3/hr (42.4 cu ft/hr) is assumed, as provided in ICRP Report No. 23, *Report of the Task Group on Reference Man* (Ref. 25).

Table 6-5 1999 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor)

AP-2001	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-2.00E-11 +/- 2.81E-11	-2.73E-11 +/- 2.56E-11	2.80E-11 +/- 3.59E-11	-1.10E-11 +/- 2.07E-11	-7.57E-12 +/- 5.63E-11	3.30E-09	-0.23%
Ra-228	-8.20E-12 +/- 5.74E-11	-1.17E-11 +/- 6.76E-11	8.96E-11 +/- 7.79E-11	-4.31E-11 +/- 8.68E-11	6.63E-12 +/- 1.47E-10	5.90E-09	0.11%
Th-228	-3.10E-11 +/- 1.17E-10	2.16E-12 +/- 3.76E-11	3.58E-12 +/- 4.67E-11	3.21E-11 +/- 6.43E-11	1.71E-12 +/- 1.46E-10	3.10E-09	0.06%
Th-230	2.82E-11 +/- 1.22E-10	-3.14E-11 +/- 1.12E-10	1.70E-11 +/- 1.21E-10	5.21E-11 +/- 7.94E-11	1.65E-11 +/- 2.20E-10	3.40E-09	0.48%
Th-232	-1.45E-11 +/- 9.83E-11	-1.33E-13 +/- 3.26E-11	-8.02E-13 +/- 2.59E-11	2.58E-11 +/- 5.49E-11	2.61E-12 +/- 1.20E-10	6.20E-10	0.42%
U, total	6.81E-11 +/- 1.40E-11	-2.78E-11 +/- 1.24E-11	4.59E-11 +/- 6.01E-12	9.99E-11 +/- 1.18E-11	4.65E-11 +/- 2.29E-11	7.98E-09	0.58%
						Total :	1.43%

AP-2005	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	2.68E-12 +/- 3.03E-11	-2.68E-11 +/- 2.52E-11	-1.50E-12 +/- 6.40E-12	-2.20E-11 +/- 2.00E-11	-1.19E-11 +/- 4.47E-11	3.30E-09	-0.36%
Ra-228	1.89E-10 +/- 1.18E-10	-1.19E-11 +/- 6.66E-11	-2.06E-11 +/- 3.79E-11	-4.35E-11 +/- 7.90E-11	2.82E-11 +/- 1.61E-10	5.90E-09	0.48%
Th-228	-2.37E-11 +/- 1.16E-10	3.67E-12 +/- 5.71E-11	4.62E-12 +/- 6.01E-11	1.22E-11 +/- 5.58E-11	-8.17E-13 +/- 1.53E-10	3.10E-09	-0.03%
Th-230	3.13E-11 +/- 1.32E-10	-4.09E-11 +/- 1.04E-10	2.79E-11 +/- 1.50E-10	3.79E-11 +/- 9.41E-11	1.40E-11 +/- 2.44E-10	3.40E-09	0.41%
Th-232	-3.59E-11 +/- 8.90E-11	4.61E-13 +/- 3.97E-11	8.65E-13 +/- 3.89E-11	1.56E-11 +/- 5.84E-11	-4.75E-12 +/- 1.20E-10	6.20E-10	-0.77%
U, total	6.02E-11 +/- 1.36E-11	3.10E-12 +/- 1.06E-11	4.88E-11 +/- 5.79E-12	8.19E-11 +/- 2.01E-11	4.85E-11 +/- 2.71E-11	7.98E-09	0.61%
						Total :	0.34%

AP-4006	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-1.98E-11 +/- 2.92E-11	-2.97E-11 +/- 2.84E-11	1.03E-11 +/- 1.62E-11	-2.12E-11 +/- 2.01E-11	-1.51E-11 +/- 4.82E-11	3.30E-09	-0.46%
Ra-228	1.86E-10 +/- 1.33E-10	-1.37E-11 +/- 6.72E-11	2.87E-12 +/- 6.66E-11	7.51E-12 +/- 1.87E-10	4.56E-11 +/- 2.48E-10	5.90E-09	0.77%
Th-228	-3.47E-11 +/- 1.07E-10	3.00E-12 +/- 3.76E-11	6.04E-12 +/- 3.76E-11	1.07E-11 +/- 6.56E-11	-3.74E-12 +/- 1.36E-10	3.10E-09	-0.12%
Th-230	-2.25E-11 +/- 9.31E-11	-3.64E-11 +/- 1.06E-10	3.90E-11 +/- 1.28E-10	3.46E-11 +/- 1.10E-10	3.67E-12 +/- 2.20E-10	3.40E-09	0.11%
Th-232	-4.99E-11 +/- 7.35E-11	-3.86E-13 +/- 3.80E-11	3.44E-12 +/- 4.00E-11	7.54E-12 +/- 5.65E-11	-9.83E-12 +/- 1.08E-10	6.20E-10	-1.59%
U, total	1.80E-11 +/- 2.52E-11	-1.22E-11 +/- 9.84E-12	4.21E-11 +/- 5.18E-12	4.40E-11 +/- 1.77E-11	2.30E-11 +/- 3.28E-11	7.98E-09	0.29%
						Total :	-0.99%

AP-4007	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	2.14E-11 +/- 3.32E-11	-2.27E-11 +/- 2.90E-11	4.76E-12 +/- 8.13E-12	3.68E-11 +/- 3.59E-11	1.01E-11 +/- 5.74E-11	3.30E-09	0.31%
Ra-228	7.62E-11 +/- 9.91E-11	-1.11E-11 +/- 6.58E-11	2.67E-10 +/- 9.54E-11	1.65E-12 +/- 1.46E-10	8.36E-11 +/- 2.11E-10	5.90E-09	1.42%
Th-228	1.38E-11 +/- 1.34E-10	1.36E-12 +/- 4.61E-11	2.11E-12 +/- 4.08E-11	4.05E-11 +/- 5.09E-11	1.44E-11 +/- 1.56E-10	3.10E-09	0.47%
Th-230	2.42E-11 +/- 1.47E-10	-2.86E-11 +/- 1.15E-10	-6.86E-12 +/- 1.06E-10	3.98E-11 +/- 7.88E-11	7.13E-12 +/- 2.28E-10	3.40E-09	0.21%
Th-232	7.22E-12 +/- 1.35E-10	8.18E-13 +/- 4.34E-11	1.70E-12 +/- 2.57E-11	4.39E-11 +/- 6.39E-11	1.34E-11 +/- 1.58E-10	6.20E-10	2.16%
U, total	1.18E-10 +/- 1.42E-11	-2.31E-11 +/- 1.00E-11	2.74E-11 +/- 7.85E-12	5.74E-11 +/- 4.08E-12	4.50E-11 +/- 1.95E-11	7.98E-09	0.56%
						Total :	5.12%

Table 6-5 1999 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor) (continued)

AP-4008	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-1.37E-11 +/- 3.47E-11	-8.40E-12 +/- 2.89E-11	3.36E-12 +/- 7.19E-12	3.46E-11 +/- 5.11E-11	3.96E-12 +/- 6.86E-11	3.30E-09	0.12%
Ra-228	2.06E-10 +/- 1.05E-10	8.87E-12 +/- 9.22E-11	2.79E-11 +/- 5.72E-11	5.20E-11 +/- 1.47E-10	7.37E-11 +/- 2.11E-10	5.90E-09	1.25%
Th-228	-3.91E-11 +/- 1.05E-10	2.55E-12 +/- 4.36E-11	2.40E-12 +/- 5.44E-11	1.23E-11 +/- 6.12E-11	-5.46E-12 +/- 1.40E-10	3.10E-09	-0.18%
Th-230	-2.81E-12 +/- 1.13E-10	-2.22E-12 +/- 1.15E-10	3.93E-11 +/- 1.27E-10	1.50E-11 +/- 1.09E-10	1.23E-11 +/- 2.33E-10	3.40E-09	0.36%
Th-232	-2.55E-11 +/- 8.96E-11	-1.17E-14 +/- 3.91E-11	5.19E-13 +/- 2.09E-11	9.37E-12 +/- 8.26E-11	-3.91E-12 +/- 1.30E-10	6.20E-10	-0.63%
U, total	3.01E-11 +/- 1.37E-11	-7.96E-12 +/- 1.02E-11	4.29E-11 +/- 6.75E-12	6.66E-11 +/- 1.75E-11	3.29E-11 +/- 2.54E-11	7.98E-09	0.41%
						Total :	1.34%

AP-4011	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-6.78E-12 +/- 2.91E-11	-1.26E-11 +/- 3.14E-11	-9.53E-13 +/- 7.16E-12	2.80E-11 +/- 5.06E-11	1.91E-12 +/- 6.66E-11	3.30E-09	0.06%
Ra-228	8.25E-12 +/- 7.75E-11	-1.11E-11 +/- 6.63E-11	-1.23E-11 +/- 4.61E-11	6.60E-11 +/- 1.57E-10	1.27E-11 +/- 1.93E-10	5.90E-09	0.22%
Th-228	-2.73E-11 +/- 1.07E-10	4.32E-12 +/- 5.00E-11	8.63E-14 +/- 4.91E-11	1.99E-11 +/- 9.41E-11	-7.43E-13 +/- 1.59E-10	3.10E-09	-0.02%
Th-230	1.10E-11 +/- 1.24E-10	-5.26E-12 +/- 1.15E-10	9.17E-12 +/- 1.32E-10	7.51E-12 +/- 8.41E-11	5.61E-12 +/- 2.31E-10	3.40E-09	0.17%
Th-232	-4.07E-11 +/- 8.92E-11	8.52E-13 +/- 4.04E-11	-2.20E-12 +/- 2.70E-11	7.02E-12 +/- 6.71E-11	-8.77E-12 +/- 1.22E-10	6.20E-10	-1.41%
U, total	3.87E-11 +/- 1.50E-11	-1.82E-11 +/- 1.01E-11	9.18E-12 +/- 5.28E-12	1.65E-10 +/- 1.42E-11	4.88E-11 +/- 2.36E-11	7.98E-09	0.61%
						Total :	-0.39%

AP-4013	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-1.89E-11 +/- 3.32E-11	-6.83E-12 +/- 2.96E-11	3.09E-12 +/- 8.74E-12	2.24E-11 +/- 3.55E-11	-7.15E-14 +/- 5.76E-11	3.30E-09	0.00%
Ra-228	6.95E-12 +/- 7.58E-11	-1.11E-11 +/- 6.75E-11	3.27E-11 +/- 4.19E-11	5.34E-11 +/- 5.63E-11	2.05E-11 +/- 1.23E-10	5.90E-09	0.35%
Th-228	-3.30E-11 +/- 1.18E-10	1.18E-12 +/- 4.97E-11	-1.78E-12 +/- 5.36E-11	8.77E-11 +/- 1.22E-10	1.35E-11 +/- 1.85E-10	3.10E-09	0.44%
Th-230	-3.21E-11 +/- 8.89E-11	-2.58E-12 +/- 1.15E-10	4.91E-12 +/- 1.21E-10	5.74E-11 +/- 9.12E-11	6.90E-12 +/- 2.10E-10	3.40E-09	0.20%
Th-232	-5.81E-11 +/- 7.00E-11	-1.24E-12 +/- 4.57E-11	-2.86E-12 +/- 2.82E-11	1.79E-12 +/- 5.53E-11	-1.51E-11 +/- 1.04E-10	6.20E-10	-2.44%
U, total*	1.36E-11 +/- 1.53E-11	4.74E-12 +/- 1.73E-11	-3.27E-13 +/- 4.77E-12	6.65E-09 +/- 2.77E-10	1.67E-09 +/- 2.78E-10	7.98E-09	20.90%
						Total :	19.45%

AP-4012 (bkg.)	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(Ci/m3)	of Limit)
Ra-226	3.92E-11 +/- 2.12E-11	4.24E-11 +/- 2.22E-11	3.91E-12 +/- 5.16E-12	2.96E-11 +/- 1.92E-11	2.88E-11 +/- 3.66E-11	NA	NA
Ra-228	2.93E-11 +/- 4.75E-11	3.60E-11 +/- 5.72E-11	3.14E-11 +/- 3.44E-11	6.59E-11 +/- 3.10E-11	4.07E-11 +/- 8.76E-11	NA	NA
Th-228	5.80E-11 +/- 9.46E-11	1.54E-11 +/- 3.74E-11	1.65E-11 +/- 3.75E-11	2.48E-11 +/- 4.10E-11	2.87E-11 +/- 1.16E-10	NA	NA
Th-230	4.53E-11 +/- 8.11E-11	6.51E-11 +/- 8.45E-11	3.94E-11 +/- 8.29E-11	4.93E-11 +/- 6.12E-11	4.98E-11 +/- 1.56E-10	NA	NA
Th-232	6.69E-11 +/- 6.54E-11	1.31E-11 +/- 3.25E-11	1.50E-11 +/- 2.05E-11	1.97E-11 +/- 4.77E-11	2.87E-11 +/- 8.96E-11	NA	NA
U, total	1.84E-10 +/- 1.35E-11	1.59E-10 +/- 9.80E-12	1.72E-10 +/- 4.60E-12	3.60E-12 +/- 3.43E-12	1.30E-10 +/- 1.77E-11	NA	NA

* Total uranium data for 4th quarter at AP-4013 is believed to be artificially high due to sample contamination.

Notes:

1) Net concentrations are calculated by subtracting background levels (i.e., levels measured at Station AP-4012) from gross concentrations measured at each critical receptor.
2) NESHAPs limits are extracted from 40 CFR 61, Subpart H, Appendix E; Table 2.
3) To convert uCi/m3 to Bq/m3, multiply concentration by 37,000.

Table 6-6 shows the CEDEs and associated errors calculated for each quarter at each critical receptor location. No dose equivalent is calculated for concentrations measured at the background location, since the purpose of this analysis is to estimate CEDEs in excess of naturally occurring background levels. At locations where several different exposure scenarios have been identified (e.g., at the high school and the wildlife area), dose equivalents are calculated only for the individual exposed for the maximum duration. In cases where net measured concentrations are negative (i.e., below background), the resulting dose equivalent is assumed to be zero.

Total annual CEDEs are calculated by summing the quarterly contributions of each radionuclide at each monitoring location. Total errors are derived by calculating the square root of the sum of the squares. The highest annual CEDE to a member of the public during 1999 is estimated to be 0.33 mrem (0.003 mSv), based on the exposure scenario of an individual residing near the Busch Memorial Conservation Area. (The dose listed for the Francis Howell High School Annex has been disregarded, due to the artificially high fourth quarter results.)

6.4.4 Compliance Assessment

Subpart H of 40 CFR 61 states the following: "*emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.*" According to DOE Order 5400.5, the total effective dose equivalent (TEDE) includes the 50-year CEDE from internal deposition of radionuclides and the effective dose equivalent (EDE) due to penetrating radiation from sources external to the body. Because the WSSRAP emits no radionuclides that could result in an appreciable submersion dose potential to members of the public, the external dose equivalent portion of the TEDE is not applicable to NESHAPs dose calculations. In addition, ingestion of radionuclides other than radon is not an applicable pathway for a potentially maximally exposed individual at any critical receptors. Thus, for the purpose of demonstrating NESHAPs compliance, the EDE specified in 40 CFR 61 is assumed to equal the CEDE from internal deposition by the inhalation pathway. The EDE contribution of dose due to external sources is discussed separately in Section 5 and Appendix B.

Results of isotopic radionuclide monitoring at critical receptor locations demonstrate that airborne emissions from the WSSRAP contributed a maximum CEDE of 0.33 mrem/yr. This value, which represents the maximum CEDE calculated for any critical receptor locations during 1999, is significantly below the NESHAPs limit of 10 mrem/yr.

All 1999 critical receptor monitoring data used to calculate CEDEs and demonstrate compliance with the 10-mrem/yr standard meet the criteria specified in 40 CFR 61, Subpart H, for monitoring and test procedures (including a quality assurance program), compliance and

Table 6-6 1999 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions at Each Critical Receptor)

AP-2001	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0001 +/- 0.0002	0.0000 +/- 0.0001	0.0001 +/- 0.0003
Ra-228	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0003 +/- 0.0000	0.0000 +/- 0.0001	0.0003 +/- 0.0003
Th-228	0.0000 +/- 0.0002	0.0003 +/- 0.0002	0.0005 +/- 0.0001	0.0048 +/- 0.0001	0.0057 +/- 0.0003
Th-230	0.0055 +/- 0.0007	0.0000 +/- 0.0007	0.0033 +/- 0.0002	0.0102 +/- 0.0008	0.0190 +/- 0.0013
Th-232	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0254 +/- 0.0002	0.0254 +/- 0.0002
U, total	0.0051 +/- 0.0007	0.0000 +/- 0.0007	0.0035 +/- 0.0002	0.0075 +/- 0.0011	0.0161 +/- 0.0015
Total EDE	0.0106 +/- 0.0002	0.0003 +/- 0.0002	0.0077 +/- 0.0000	0.0479 +/- 0.0002	0.0666 +/- 0.0003

AP-2005	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0000 +/- 0.0000	0.0000 +/- 0.0001	0.0000 +/- 0.0003
Ra-228	0.0007 +/- 0.0004	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0000 +/- 0.0003	0.0007 +/- 0.0006
Th-228	0.0000 +/- 0.0217	0.0007 +/- 0.0107	0.0009 +/- 0.0113	0.0023 +/- 0.0105	0.0038 +/- 0.0287
Th-230	0.0077 +/- 0.0321	0.0000 +/- 0.0254	0.0068 +/- 0.0365	0.0093 +/- 0.0230	0.0237 +/- 0.0595
Th-232	0.0000 +/- 0.1095	0.0006 +/- 0.0488	0.0011 +/- 0.0478	0.0191 +/- 0.0718	0.0208 +/- 0.1477
U, total	0.0057 +/- 0.0013	0.0003 +/- 0.0010	0.0046 +/- 0.0005	0.0077 +/- 0.0019	0.0182 +/- 0.0025
Total EDE	0.0140 +/- 0.1161	0.0015 +/- 0.0561	0.0133 +/- 0.0612	0.0384 +/- 0.0761	0.0673 +/- 0.1618

AP-4006	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0000 +/- 0.0001	0.0001 +/- 0.0003
Ra-228	0.0006 +/- 0.0004	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0000 +/- 0.0006	0.0006 +/- 0.0008
Th-228	0.0000 +/- 0.0180	0.0005 +/- 0.0063	0.0010 +/- 0.0063	0.0018 +/- 0.0111	0.0033 +/- 0.0229
Th-230	0.0000 +/- 0.0205	0.0000 +/- 0.0232	0.0086 +/- 0.0282	0.0076 +/- 0.0243	0.0162 +/- 0.0484
Th-232	0.0000 +/- 0.0814	0.0000 +/- 0.0421	0.0038 +/- 0.0443	0.0083 +/- 0.0625	0.0121 +/- 0.1194
U, total	0.0015 +/- 0.0021	0.0000 +/- 0.0008	0.0036 +/- 0.0004	0.0037 +/- 0.0015	0.0088 +/- 0.0028
Total EDE	0.0021 +/- 0.0858	0.0005 +/- 0.0485	0.0170 +/- 0.0529	0.0215 +/- 0.0679	0.0412 +/- 0.1309

AP-4007	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0005 +/- 0.0007	0.0000 +/- 0.0007	0.0001 +/- 0.0002	0.0008 +/- 0.0008	0.0014 +/- 0.0013
Ra-228	0.0010 +/- 0.0012	0.0000 +/- 0.0008	0.0034 +/- 0.0012	0.0000 +/- 0.0018	0.0043 +/- 0.0026
Th-228	0.0091 +/- 0.0880	0.0009 +/- 0.0302	0.0014 +/- 0.0268	0.0266 +/- 0.0334	0.0379 +/- 0.1024
Th-230	0.0207 +/- 0.1256	0.0000 +/- 0.0983	0.0000 +/- 0.0906	0.0341 +/- 0.0674	0.0547 +/- 0.1954
Th-232	0.0311 +/- 0.5825	0.0035 +/- 0.1870	0.0073 +/- 0.1107	0.1890 +/- 0.2752	0.2310 +/- 0.6799
U, total	0.0389 +/- 0.0047	0.0000 +/- 0.0033	0.0090 +/- 0.0026	0.0189 +/- 0.0013	0.0669 +/- 0.0064
Total EDE	0.1012 +/- 0.6023	0.0044 +/- 0.2134	0.0212 +/- 0.1456	0.2694 +/- 0.2853	0.3963 +/- 0.7148

Table 6-6 1999 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions at Each Critical Receptor) (continued)

AP-4008	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0001 +/- 0.0002	0.0001 +/- 0.0002
Ra-228	0.0004 +/- 0.0002	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0001 +/- 0.0003	0.0005 +/- 0.0004
Th-228	0.0000 +/- 0.0101	0.0002 +/- 0.0042	0.0002 +/- 0.0052	0.0012 +/- 0.0059	0.0017 +/- 0.0135
Th-230	0.0000 +/- 0.0141	0.0000 +/- 0.0144	0.0049 +/- 0.0159	0.0019 +/- 0.0137	0.0068 +/- 0.0291
Th-232	0.0000 +/- 0.0564	0.0000 +/- 0.0246	0.0003 +/- 0.0132	0.0059 +/- 0.0520	0.0062 +/- 0.0816
U, total	0.0015 +/- 0.0007	0.0000 +/- 0.0005	0.0021 +/- 0.0003	0.0032 +/- 0.0008	0.0067 +/- 0.0012
Total EDE	0.0018 +/- 0.0590	0.0003 +/- 0.0288	0.0076 +/- 0.0213	0.0124 +/- 0.0541	0.0221 +/- 0.0877

AP-4011	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0007	0.0000 +/- 0.0007	0.0000 +/- 0.0002	0.0006 +/- 0.0011	0.0006 +/- 0.0015
Ra-228	0.0001 +/- 0.0010	0.0000 +/- 0.0008	0.0000 +/- 0.0006	0.0008 +/- 0.0020	0.0009 +/- 0.0024
Th-228	0.0000 +/- 0.0700	0.0028 +/- 0.0328	0.0001 +/- 0.0322	0.0131 +/- 0.0618	0.0160 +/- 0.1041
Th-230	0.0094 +/- 0.1063	0.0000 +/- 0.0987	0.0078 +/- 0.1130	0.0064 +/- 0.0720	0.0237 +/- 0.1975
Th-232	0.0000 +/- 0.3844	0.0037 +/- 0.1741	0.0000 +/- 0.1164	0.0302 +/- 0.2890	0.0339 +/- 0.5246
U, total	0.0128 +/- 0.0049	0.0000 +/- 0.0033	0.0030 +/- 0.0017	0.0545 +/- 0.0047	0.0703 +/- 0.0078
Total EDE	0.0223 +/- 0.4050	0.0065 +/- 0.2028	0.0109 +/- 0.1654	0.1057 +/- 0.3042	0.1454 +/- 0.5701

AP-4013	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0000 +/- 0.0000	0.0001 +/- 0.0002	0.0001 +/- 0.0003
Ra-228	0.0000 +/- 0.0002	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0002 +/- 0.0002	0.0003 +/- 0.0004
Th-228	0.0000 +/- 0.0177	0.0002 +/- 0.0075	0.0000 +/- 0.0080	0.0131 +/- 0.0183	0.0133 +/- 0.0277
Th-230	0.0000 +/- 0.0174	0.0000 +/- 0.0225	0.0010 +/- 0.0236	0.0112 +/- 0.0178	0.0122 +/- 0.0410
Th-232	0.0000 +/- 0.0689	0.0000 +/- 0.0450	0.0000 +/- 0.0277	0.0018 +/- 0.0544	0.0018 +/- 0.1025
U, total*	0.0010 +/- 0.0012	0.0004 +/- 0.0013	0.0000 +/- 0.0004	0.5006 +/- 0.0208	0.5020 +/- 0.0209
Total EDE	0.0010 +/- 0.0732	0.0005 +/- 0.0509	0.0011 +/- 0.0373	0.5270 +/- 0.0636	0.5296 +/- 0.1157

*Dose contribution from total uranium during 4th quarter at AP-4013 is believed to be artificially high due to sample contamination.

Notes:

1) Monitor locations and exposure scenarios are listed in Table 6-3. For critical receptors with more than one exposure scenario, the exposure of greatest duration is used to calculate dose.
2) Dose calculations are based on inhalation pathway. Dose conversion factors are from FGR11.
3) No dose is calculated for AP-4012, since it represents background conditions.
4) Assume breathing rate of 1.2 m^3/hr, as provided in ICRP 23.
5) In cases where net measured concentrations are below background, dose is listed as zero.
6) To convert mrem to mSv, multiply dose by 0.01.

reporting procedures, and record keeping requirements. In addition, as mentioned in Section 6.4.2, net measured concentrations of individual radioisotopes are all below the limiting levels and proportional limits specified in 40 CFR 61, Subpart H, Appendix E, Table 2.

Data quality objectives for precision and accuracy, as outlined in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 20), have been achieved for all four quarters of the year. Based on verification and validation of each reported value, overall completeness of the data is greater than 95%. One-tailed Student's t-tests performed at the 95% confidence level indicate that no quarterly or annual concentrations are statistically above background at any of the critical receptors, except for the elevated uranium data collected from AP-4013 during the fourth quarter (discussed in Section 6.4.2).

Potential emission sources of radioactive particulates will be substantially reduced or eliminated by the end of the year 2000. Accordingly, it is anticipated that NESHAPs critical receptor monitoring will be discontinued at that time.

7. SURFACE WATER PROTECTION

7.1 Highlights of the Surface Water Program

The following are highlights of the 1999 surface water program. These items, and others, are discussed in detail in this chapter.

- The mass of uranium migrating off site in storm water and treated effluent, 9.56 kg/yr (21.08 lb/yr), was less than half the 1998 mass of 23.8 kg/yr (52.4 lb/yr) (see Tables 7-5 and 11-1) and a 97.8% reduction from the 1987 mass of 442 kg.

- Thirty-nine samples of water were collected from the site and quarry water treatment plants during 1999. All parameters, except selenium in one sample and settleable solids in two samples, were in compliance with National Pollutant Discharge Elimination System (NPDES) permit conditions.

- The overall results of the whole effluent toxicity (WET) tests indicate that the site and quarry water treatment plant effluents were not toxic to test organisms during 1999.

7.2 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) is prescribed in the *Environmental Monitoring Plan* (Ref. 8) and includes monitoring discharge points permitted under the NPDES program and streams, ponds, and lakes under the surface water monitoring program.

The NPDES effluent monitoring program at the Weldon Spring site establishes sampling requirements for discharge points (outfalls) at both the chemical plant and the quarry. The goals of this program are to maintain compliance with the NPDES permit requirements and to protect the health of downstream water users and the environment by characterizing water released from the site. In accordance with the WSSRAP policy that all surface water be closely monitored and treated (as necessary) to meet Federal and State requirements, the Project Management Contractor (PMC) uses the water sample data to develop strategies to minimize the discharge of waterborne contaminants from the site.

In addition, the surface water monitoring program monitors off-site water bodies for uranium contamination and temporal changes in uranium levels. The data generated from this monitoring are used in conjunction with NPDES monitoring to measure the success of the project's goal to clean up the site with no long-term increase in contaminant discharge or degradation of the off-site water bodies.

7.3 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 1999 were authorized by four NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be monitored at outfalls listed in each permit. Each parameter is assigned either effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 and MO-0108987, are summarized in Tables 7-1 and 7-2. These permits were reissued on March 4, 1994, and June 17, 1998, respectively. An application to renew Permit MO-0107701 was submitted on September 1, 1998, and renewal is pending.

The Borrow Area land disturbance storm water permit, MO-R100B69, issued on September 1, 1994, and reissued on May 29, 1998, has no specified monitoring or reporting requirements. A program was developed in the *Environmental Monitoring Plan* (Ref. 8) for monitoring settleable solids and, under certain circumstances, oil and grease. The results of this monitoring were used to measure the effectiveness of erosion control and to improve controls, if required.

Permit MO-G670203 was issued on December 5, 1997, for the discharge of hydrostatic test water from the chemical plant site. Sampling frequency and reporting requirements and results are discussed in Section 7.6.1.2.4.

Effluent discharges are also regulated by Department of Energy (DOE) Order 5400.5, which calls for a best available technology evaluation if the annual average uranium concentration at an outfall exceeds the derived concentration guideline (DCG) for natural uranium (600 pCi/l [22.2 Bq/l]). Measures are taken to keep uranium concentrations as low as reasonably achievable (ALARA) not just below the DCG.

The primary criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards for drinking water supplies established under the Missouri Clean Water Commission Regulation 10 CSR 20-7.031 and the U.S. Environmental Protection Agency primary and secondary maximum contaminant level concentrations for drinking water. A table of applicable drinking water standards that includes contaminants routinely monitored in the surface water program can be found in Section 8.

Surface water other than NPDES outfalls is also monitored under the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates DCGs for ingestion of water.

Table 7-1 Weldon Spring Chemical Plant Storm and Sanitary Water (NPDES Permit MO-0107701) and Quarry Storm Water (MO-0108987) Monitoring Requirements

PARAMETER	LOCATION	
	NP-0002, NP-0003[d], NP-0004, NP-0005, NP-0010, NP-0050[f] NP-1005	**NP-0006**
Sampling Frequency	once/quarter	Once/quarter
Flow	GPD (monitor only)	GPD (monitor only)[a]
Settleable Solids	1.0 ml/l/hr	---
TSS	mg/l (monitor only)[b]	30/45 mg/l[e]
Nitrate and Nitrite as N**	mg/l (monitor only)	---
Uranium, total	mg/l (monitor only)*	---
Gross alpha, beta	pCi/l (monitor only)	---
pH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	---	400/1000 colonies/ 100 ml[c]
BOD	---	30/45 mg/l[e]

NOTE: Refer to Figure 7-1 for NPDES monitoring locations.

* Permit requires reporting in both mg/l and pCi/l and notification of MDNR if uranium concentration in any sample exceeds 2 mg/l.
** Does not apply to quarry storm water Outfall NP-1005.
(a) Frequency is once/month.
(b) Limit is 50 mg/l if erosion control is not designed for a one in 10 year, 24-hour storm.
(c) Monthly average/daily maximum.
(d) NPDES permit MO-0107701 includes sampling of creosote constituents, Cu and Zn in the chipped wood storage area pond prior to discharge to Outfall NP-0003. See Table 7-2 for limits.
(e) Monthly average/weekly average.
(f) Outfall NP-0050 is an outfall from the TSA. Application has been made to add the outfall to permit MO-0107701, but the permit was not issued during 1999. Permission was given by MDNR to discharge at the outfall as long as it was monitored as at other storm water outfalls. Outfall NP-0050 represents two outfalls from the TSA.
--- Not Applicable.

Table 7-2 Effluent Parameter Limits and Monitoring Requirements for Site Water Treatment Plant (NPDES Permit MO-0107701) and Quarry Water Treatment Plant (NPDES Permit MO-0108987) Outfalls*

PARAMETER	LOCATION NP-0007/NP-1001	PARAMETER	LOCATION NP-0007/NP-1001
Gross α	pCi/l[a]	Pb, total	0.20/0.10 mg/l
Gross β	pCi/l[a]	Mn, total	0.50/0.10 mg/l
Uranium, total	pCi/l[a][b]	Hg, total	0.005/0.004 mg/l
Ra-226[c]	pCi/l[a]	Se, total	0.05 mg/l/NA
Ra-228[c]	pCi/l[a]	Cyanide, Amenable	0.5 mg/l/NA
Th-230[c]	pCi/l[a]	2,4-DNT	1.1/0.22 µg/l
Th-232[c]	pCi/l[a]	Fluoride, total	12 mg/l/NA
Flow	GPD[a]	Nitrate and Nitrite as N	100 mg/l[g]
COD	90 (60) mg/l [e]	Sulfate as SO_4	1000/500 mg/l
TSS	50 (30) mg/l[e]	Chloride	mg/l[a]/NA
pH	6-9 standard units	Priority Pollutants[f]	mg/l[a][h][d]
As, total	0.20 mg/l/NA	Whole Effluent Toxicity	[i][j]
Cr, total	0.40 mg/l/NA	Creosote-site[l]	[m][k]
Cu-Site	1.0(0.66) mg/l[e][k]	Zn-Site	5.0(3.33) mg/l[e][k]

NOTE: Refer to Figures 7-2 and 7-3 for NPDES monitoring locations.

* Frequency = once per batch unless otherwise noted.
(a) Monitoring only.
(b) Water treatment plants designed for an average concentration of 30 pCi/l (1.11 Bq/l) and never to exceed concentrations of 100 pCi/l (3.7 Bq/l).
(c) Once/month.
(d) Polychlorinated biphenyls (PCBs) have a limit of 1 µg/l.
(e) Daily maximum (monthly average).
(f) Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.
(g) Limit applies to chemical plant; monitoring only at quarry.
(h) Annual monitoring.
(i) Quarterly monitoring.
(j) "No statistical difference between effluent and upstream results at 95% confidence level."
(k) Once per batch for each batch sampled within a period of 30 days following introduction of CWSA water (which has failed these limits) to the SWTP.
(l) Includes: acenaphthylene, acenaphthene, benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(a)pyrene, benzo (k) fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, and phenanthrene.
(m) Daily maximum - 2.5 x Q.L., monthly average - 1.5 x Q.L. Q.L. - quantification level as set by most recent edition of Standard Methods (Q.L. taken as practical quantification limit [PQL]).

7.4 Hydrology Description of the Site and Quarry

Separate surface water monitoring programs have been developed at the chemical plant and quarry due to differences in the topography and hydrologic conditions. Both programs take into account the mechanisms controlling surface water source areas.

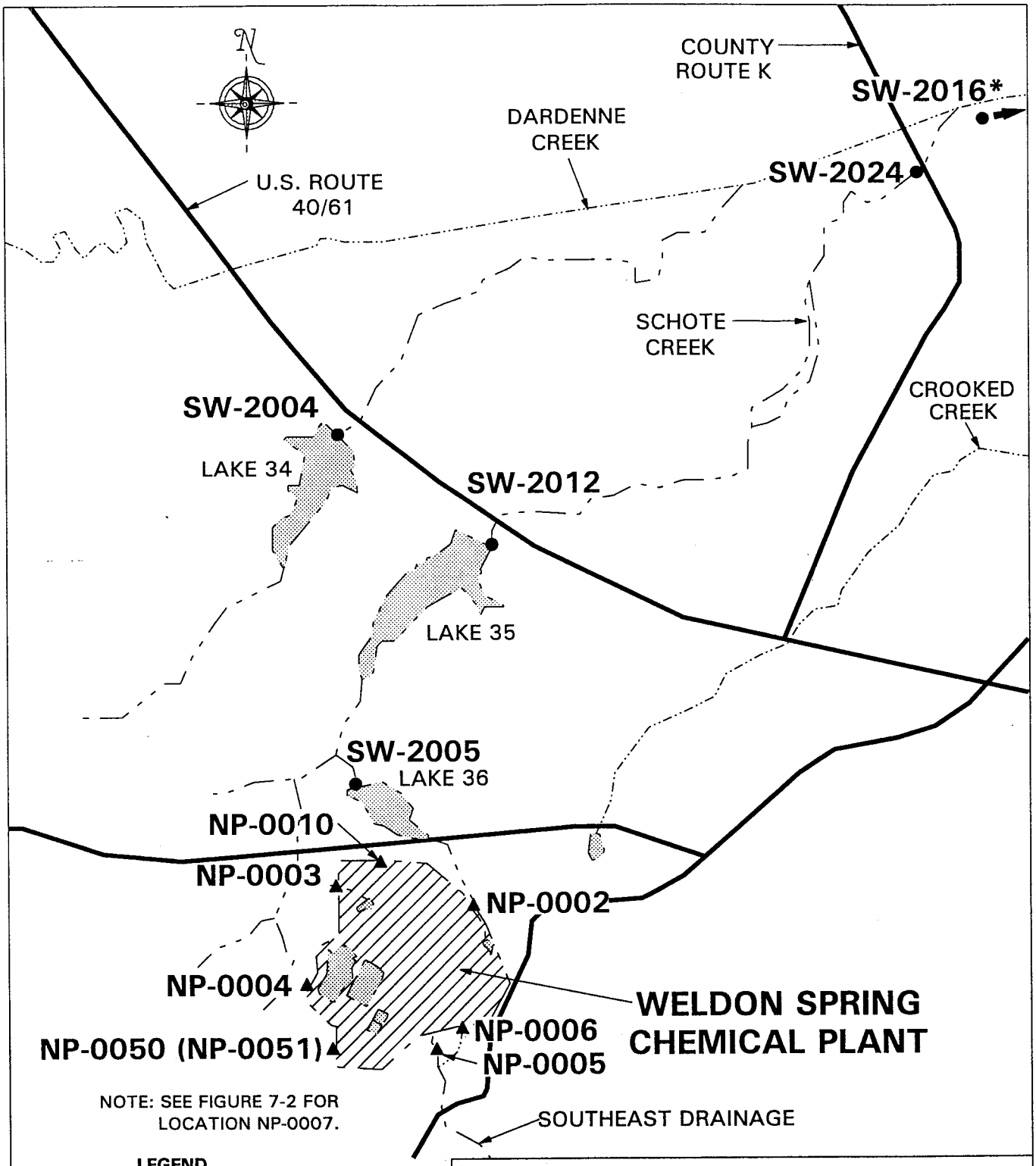
7.4.1 Weldon Spring Chemical Plant and Raffinate Pits

The chemical plant area is located on the Missouri-Mississippi River surface drainage divide (Figures 7-1 and 7-2). The topography is gently undulating and generally slopes northward to the Mississippi River and, more steeply, southward to the Missouri River. Streams do not run through the property, but because the site is elevated above surrounding areas, drainageways originate on the property and convey storm water off site. Surface drainage from the western portion of the site, which included Ash Pond, the chipped wood storage area (CWSA), the TSA, areas adjacent to the TSA, and the raffinate pits drains to tributaries of Busch Lake 35 and then to Schote Creek, which in turn enters Dardenne Creek, ultimately draining to the Mississippi River (Figure 7-1).

Ash Pond, Raffinate Pits 3 and 4, and the CWSA were completely remediated and confirmed clean during 1999. The south portion of the TSA was also remediated and confirmed clean. During 1999, water accumulated in Ash Pond when a valve was closed in the discharge structure. If Ash Pond water had a uranium concentration greater than 600 pCi/l (22.2 Bq/l), the valve remained closed. If the ponded water was below 600 pCi/l after the runoff event, it was released; otherwise it was stored in the pond or transferred for treatment. The CWSA basin was operated by sampling for parameters prescribed in permit MO-0107701. If the parameters were within limits the water was discharged to the Ash Pond diversion channel. The water was always in compliance during 1999. If it had not been in compliance, the water would have been transferred for treatment. All water that discharges at NP-0003 flows through Sedimentation Basin 4 before reaching Outfall NP-0003. Outfalls NP-0004, NP-0005, NP-0010 and NP-0050, and NP-0051 do not have sedimentation basins but have appropriate vegetation and/or erosion control upstream of the outfalls.

Surface water drainage from the north and east sections of the chemical plant, which includes the administration parking lots and part of the disposal cell outer berm and the CMSA, discharges to Dardenne Creek from Schote Creek after first flowing through Busch Lakes 36 and 35 (Figures 7-1 and 7-2). Frog Pond and the asbestos storage area were removed from the watershed during August 1998 and the areas were remediated. Storm water runoff and leachate from the interior of the cell is collected in Retention Basins 1 and 2, and Sedimentation Basin 1 (converted to a retention basin) for sampling and/or treatment. Runoff from the CMSA equipment area near the north decontamination pad is collected in the CMSA retention basin and sampled to ensure compliance before being discharged to Outfall NP-0010.

Runoff from the southern portion of the chemical plant site (Figures 7-1 and 7-2), which includes the site water treatment plant, Building 434, and parking and equipment areas for the former Chemical Stabilization and Solidification (CSS) Facility, flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). All storm water runoff from this area, except for minor flows from the Building 434 area and some roadside ditches, flowed through a sedimetation basin just upstream of Outfall NP-0005 during early 1999. In the spring of 1999



NOTE: SEE FIGURE 7-2 FOR LOCATION NP-0007.

LEGEND

- ● - SURFACE WATER LOCATION
- ▲ - NPDES LOCATION
- * - AT COUNTY ROUTE N, APPROXIMATELY 2 MILES

0 1/2 1 MI

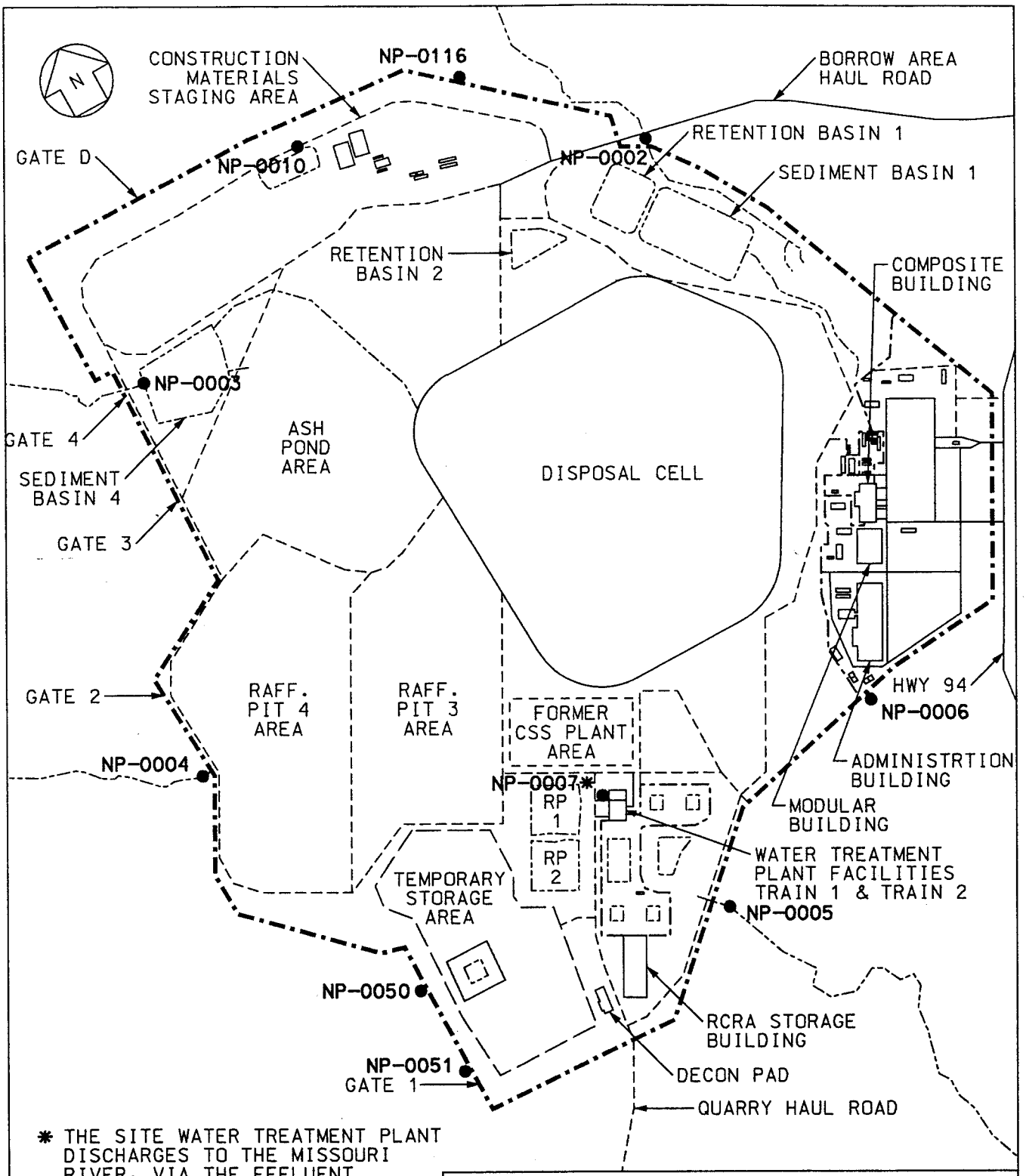
0 .8 1.6 KM

SCALE

SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS

FIGURE 7-1

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/079/1193
ORIGINATOR:	TW	DRAWN BY:	GLN
DATE:	4/21/00		



* THE SITE WATER TREATMENT PLANT DISCHARGES TO THE MISSOURI RIVER, VIA THE EFFLUENT PIPELINE AT NP-0007 (SEE FIGURE 4-2)

LEGEND

● - SAMPLE LOCATION

0 600 1200

SCALE FEET

NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT

FIGURE 7-2

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/CP/086/0993		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	5/11/00

the sedimentation basin was converted to an effluent pond for the Site Water Treatment Plant. Also during 1999, the CSS was removed and the parking area was converted to use as a laydown yard for disposal cell berm materials.

The four raffinate pits that were located in the southwestern portion of the chemical plant area did not discharge to the surface and collected only direct precipitation. During 1999 all four pits were dewatered. Pits 3 and 4 were remediated and confirmed clean, backfilled, graded and seeded. The sludge was removed from Raffinate Pits 1 and 2. Remediation of Raffinate Pits 1 and 2 will be completed during 2000. Any water accumulating in the pits will be treated before release.

7.4.2 Weldon Spring Quarry

Surface water bodies in the quarry area are the Femme Osage Slough, the Little Femme Osage Creek, and the Femme Osage Creek (Figure 7-3). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to the movement of contaminated groundwater from the fractured bedrock of the quarry through the fine-grained alluvial materials.

The Femme Osage Slough is located directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge. There is no natural surface flow from the slough; it is essentially land locked. The Little Femme Osage Creek is located west of the quarry and discharges into the Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. The Femme Osage Creek flows into the Missouri River. Although there has been no evidence of impact from contaminated groundwater on the creeks via stream emergence, they are monitored to detect any changes in the system.

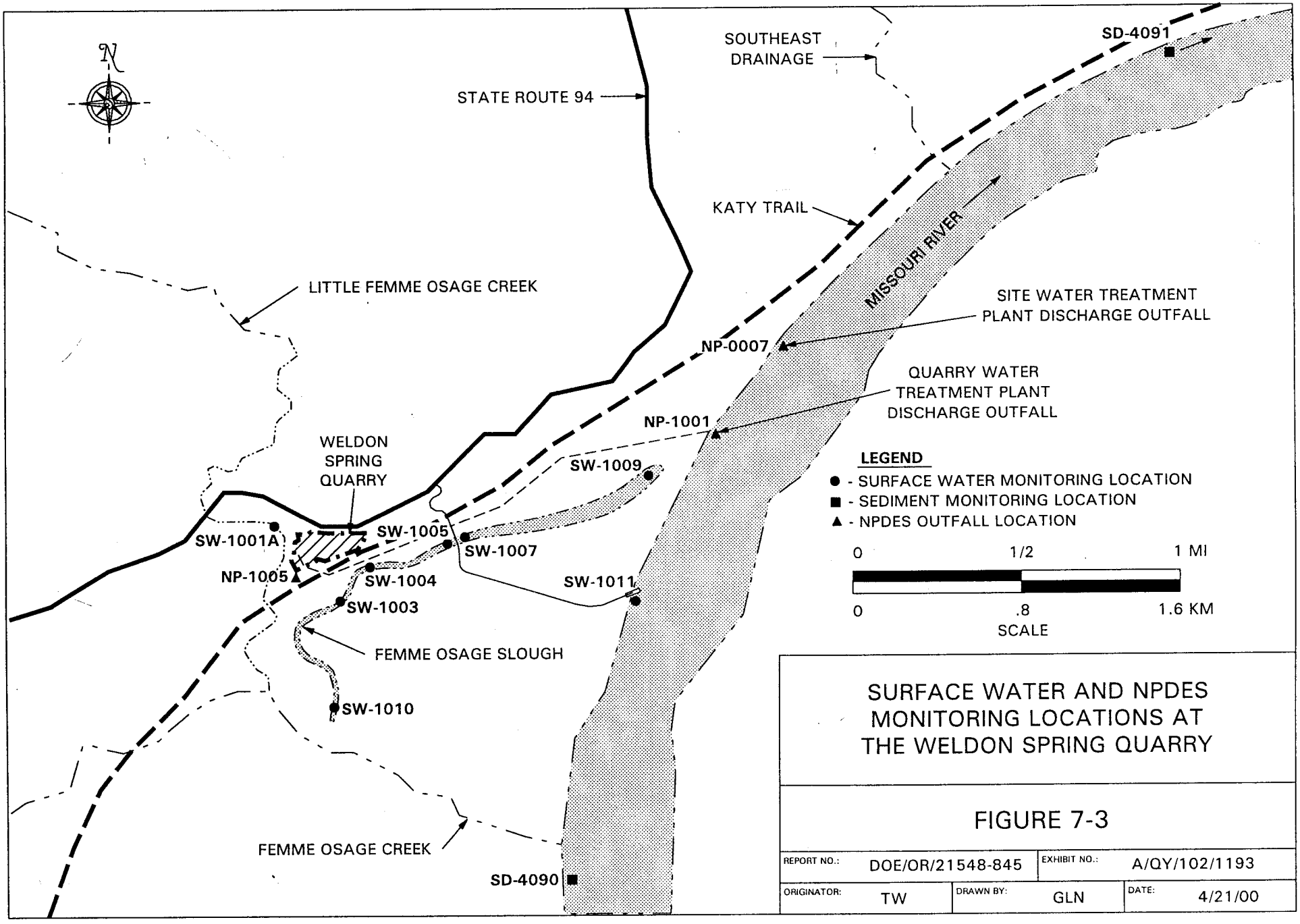
The quarry decontamination pad was not used during 1999 and was demonstrated to have no surface contamination. Storm water runoff from the quarry decontamination pad area was directed to storm water outfall NP-1005 (Figure 7-3). If the pad is used for decontamination in the future, all water will be treated until the pad is taken out of service and again demonstrated to have no surface contamination.

7.5 Monitoring

Sections 7.5.1 and 7.5.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.

7.5.1 National Pollutant Discharge Elimination System Monitoring

The NPDES permits issued to the site identify the parameters to be monitored. The permit requirements for the two major permits are shown in Tables 7-1 and 7-2, and the



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 7-3

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/QY/102/1193
ORIGINATOR:	TW	DRAWN BY: GLN	DATE: 4/21/00

requirements for the two minor permits are discussed in the text. Physical, chemical, and radiological parameters were monitored at all storm water outfalls, as well as the quarry water and site water treatment plant outfalls. The *Environmental Monitoring Plan* (Ref. 8) reflects the requirements of the NPDES permits.

In addition to the permitted outfalls, samples were scheduled to be collected upstream of NPDES storm water Outfall NP-0002 from sampling location SW-2019 (Sedimentation Basin No. 1), and upstream of NPDES storm water Outfall NP-0003 from location SW-2010 (Ash Pond) and SW-2017 (Ash Pond diversion channel). Quarterly samples were also collected from Ash Pond, when possible, to monitor the effects of remediation of materials stored in that area on contaminant levels in the storm water runoff. During 1999, to accommodate remediation, the Ash Pond diversion channel was rerouted from Sedimentation Basin 4 to Ash Pond (at the dam). This effectively routed all water in the watershed to Ash Pond where it could be sampled before discharge. Thus, the SW-2017 and SW-2010 sampling locations were deleted as upstream locations because they were essentially the same as Outfall NP-0003. Ash Pond water was still sampled quarterly but SW-2017 and SW-2010 were not sampled monthly after the diversion channel was moved. After Ash Pond was remediated, late in the year, the diversion channel was again routed to Sedimentation Basin 4.

7.5.2 Surface Water Monitoring

The following two subsections discuss surface water monitoring requirements at the chemical plant site and the quarry.

7.5.2.1 Weldon Spring Chemical Plant and Raffinate Pits

In accordance with the surface water monitoring program, Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled quarterly for total uranium (Ref. 8). Samples were analyzed on the site Kinetic Phosphorescent Analyzer (KPA). This monitoring was conducted to measure the effects of surface water discharges from the site on the quality of downstream surface water.

7.5.2.2 Weldon Spring Quarry

Six locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the quarry. Surface water locations SW-1003, SW-1004, and SW-1005 (Figure 7-3) were monitored quarterly for total uranium because of past significant contaminant levels in these areas, fluctuations in concentrations due to changes in water levels in the slough and groundwater potentiometric surface, and the potential for these surface water contaminants to impact groundwater south of the slough. The remaining locations (SW-1007, SW-1008, and SW-1009) were sampled quarterly to provide sufficient data to determine any changes in these areas. Locations SW-1003, SW-1004, and SW-1005 were also monitored semiannually for nitroaromatic compounds because these locations are downgradient from the area of greatest nitroaromatic groundwater contamination.

7.6 Monitoring Results

Analytical results of the monitoring of surface water and NPDES outfalls are presented in the following subsections.

7.6.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical, and physical analytical results for NPDES outfalls are presented in subsections 7.6.1.1 and 7.6.1.2.

7.6.1.1 Radiochemical Analysis

The 1999 average uranium concentrations at the storm water discharge points ranged from 1.9 pCi/l (0.07 Bq/l) at NP-1005 to 38.3 pCi/l (1.42 Bq/l) at NP-0003, which are 0.3% and 6.4%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 2.7 pCi/l (0.10 Bq/l) at NP-1005 to 54.6 pCi/l (2.00 Bq/l) at NP-0003. The annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 7-3.

Uranium concentration averages were calculated on a flow weighted basis for storm water Outfalls NP-0002, NP-0003 and NP-0005. These outfalls had flow totalizers. Flow weighted averages (rather than straight averages) were calculated for uranium levels at the these major outfalls to estimate the total uranium that migrated off site during 1999. The averages were flow weighted by summing the total daily flows (liters) for the days the samples were collected and summing the total activity (pCi) for the days the samples were collected. The sum of the activity for all samples was then divided by the sum of the flow for all samples, to give the flow-weighted average for the year. Straight averages and calculated total flows were used at the other storm water outfalls.

The site water treatment plant (SWTP) and quarry water treatment plant (QWTP) were both in operation during 1999. Nine batches were discharged from the QWTP and 30 batches were discharged from the SWTP. Seven of the SWTP batches were continuous discharge. No daily maximum or monthly average limits are established for uranium; however, the design of the treatment plant is based on achieving an average of 30 pCi/l (1.11 Bq/l) uranium with a maximum never to exceed 100 pCi/l (3.7 Bq/l). The average uranium concentrations for the site and quarry water treatment plants were well below this level at 17.1 pCi/l (0.63 Bq/l) and 1.1 pCi/l (0.04 Bq/l), respectively (Table 7-5). In addition, the SWTP averaged 18.0 pCi/l (0.67 Bq/l) for gross alpha and 19.0 pCi/l (0.70 Bq/l) for gross beta. The QWTP averaged 1.5 pCi/l (0.06 Bq/l) and 5.1 pCi/l (0.19 Bq/l), respectively for these same parameters (Table 7-4).

The annual averages for uranium, gross alpha, and gross beta at the site water treatment plant were higher than past year's averages due to the release of several batches of cell runoff

and leachate that required only primary treatment to meet the NPDES requirements. The DOE received permission from the MDNR to release leachate and cell runoff that met all permit limits with primary (settling) treatment only. The average for uranium in the water that was treated by the site water treatment plant was 1.65 pCi/l, in the range of previous yearly averages. Gross beta and gross alpha results were proportional to uranium results in the treated water. Uranium levels were higher in the primarily treated water than normally seen in treatment plant effluent and caused an overall increase in annual averages. The uranium level was, however, well below the 600 pCi/l DCG for uranium for every discharge. Although the NPDES permit does not have a limit for uranium there is a footnote to the Outfall 007 uranium monitoring requirements that states, "the design of the treatment plant is based on achieving an average discharge of 30 pCi/l uranium with the maximum never to exceed 100 pCi/l." This is seen by the Department of Energy as a guideline, not a limit, that applies only to treatment plant effluent. Subsequently, three batches of primarily treated leachate and cell runoff were released using the DOE administrative level of 600 pCi/l for uranium. Two of the batches, at 107 pCi/l and 290 pCi/l, were above the 100 pCi/l maximum design level specified in the footnote. The third batch contained 86.7 pCi/l.

In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted annually upstream and downstream of the quarry water treatment plant outfall (NP-1001). The river sediment was sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream) (see Figure 7-3). The one-time sampling results were 0.90 pCi/g (0.03 Bq/g) at SD-4090 and 1.33 pCi/g (0.05 Bq/g) at SD-4091.

Radium and thorium were monitored once per month, (as required by the permit) in both site and quarry water treatment plant batches. While there were some isolated instances at the site water treatment plant of somewhat elevated levels (Ra-226 had a maximum value of 2.94 pCi/l [0.11 Bq/l], Ra-228 had a maximum value of 1.84 pCi/l [0.07 Bq/l], and Th-230 had a maximum value of 10.8 pCi/l [0.40 Bq/l]), they were below DCG levels. There were also some instances of somewhat elevated levels at the quarry water treatment plant (Ra-226 had a maximum value of 3.22 pCi/l [0.12 Bq/l]), and Th-230 had a maximum level of 1.05 pCi/l [0.04 Bq/l], these also were below the DCGs. Annual averages for radium and thorium at the SWTP and QWTP are shown in Table 7-4.

Table 7-3 1999 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls

PARAMETER	LOCATIONS						
	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-1005	NP-0050, 51
Number of sample events	12	10	10	12	11	12	4
pH range	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Nitrate as N (mg/l)	1.1	3.4	33.3	2.2	0.3	NS	1.2
Total suspended solids (mg/l)	324	86	328	311	32.5	16.6	521.1
Settleable solids (ml/l/hr)	12/1(b)	10/0(b)	10/0(b)	12/1(b)	11/0(b)	12/0(b)	4/0(b)
Arsenic (mg/l)	0.0046(5)	0.0030	0.0012(1)	NS	NS	NS	0.0131
Chromium (mg/l)	0.0138(5)	0.0086	0.0033(1)	NS	NS	NS	0.0367
Lead (mg/l)	0.0062(5)	0.0035	0.0007(1)	NS	NS	NS	0.0152
Thallium (mg/l)	0.0036(5)	0.0019	0.0028(1)	NS	NS	NS	0.0029
Total uranium (pCi/l)	8.0*	38.3*	3.5	20.3*	7.3	1.9	2.7
Gross alpha (pCi/l)	20.6	54.6	14.0	41.6	13.3	2.7	22.1
Gross beta (pCi/l)	18.1	19.9	15.2	19.9	5.6	5.4	24.1
Radium-226 (pCi/l)	NS	0.52	NS	NS	NS	NS	NS
Radium-228 (pCi/l)	NS	0.48	NS	NS	NS	NS	NS
Thorium-228 (pCi/l)	NS	0.22	NS	NS	NS	NS	NS
Thorium-230 (pCi/l)	NS	1.64	NS	NS	NS	NS	NS
Thorium-232 (pCi/l)	NS	0.25	NS	NS	NS	NS	NS

(a) All pH readings were in the permitted range of 6.0 to 9.0.
(b) Top number is number of samples, bottom number is number of results above daily maximum limit of 1.0 ml/l/hr.
(c) The number in parentheses indicates the number of samples analyzed for the specified parameter, if it differs from the number of sample events.
* Flow proportional averages.
NS Not Sampled.
Note: 1 pCi/l = 0.037 Bq/l.

Table 7-4 Site and Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	QUARRY WTP (NP-1001)*	SITE WTP (NP-0007)*
Ra-226	0.23 (0/6)	0.67 (2.14)
Ra-228	0.89 (2/6)	0.60 (6/14)
Th-228	0.34 (0/6)	0.21 (1/14)
Th-230	0.48 (1/6)	1.08 (0/14)
Th-232	0.13 (4/6)	0.62 (2/14)
Gross alpha	1.5 (0/6)	18.0 (5/14)
Gross beta	5.1 (0/6)	19.0 (1/14)

* Number in parentheses represents the number of results below detection limit (including uncensored values)/total number of samples.
Note: 1 pCi/l = 0.037 Bq/l

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are presented in Table 7-5. The total volume of storm water at the three major outfalls was measured with totalizing flow meters. Where flow meters were not available, the flow was determined by total precipitation and runoff curve numbers cited in the U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 34). When flow meters were not operational for a period of time, runoff curve numbers were calculated using flow and precipitation data from periods when the meter was operational. Total uranium released from the treatment plants was calculated using flow meter and effluent concentration data. The estimated mass of uranium released off site in storm water and treated effluent during 1999 was 9.56 kg (21.08 lb). This is a substantial decrease from the calculated amount released during 1998 (23.8 kg [52.47 lb]).

Table 7-6 shows the annual average uranium concentrations of NPDES outfalls from 1992 to 1999. Uranium average concentrations for 1999, in comparison to levels for 1998,

Table 7-5 1999 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA HECTARES (ACRES)	ESTIMATED % OF PRECIPITATION AS RUNOFF	AVERAGE URANIUM CONCENTRATION (pCi/l)	TOTAL RAINFALL VOLUME Ml/yr (Mgal/yr)	TOTAL RUNOFF VOLUME Ml/yr (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (kg/yr)
NP-0002	23.9 (5.9)	(b)	8.0*	214.36 (56.63)	70.34 (18.56)	5.6E-4	0.831
NP-0003	22.2 (54.9)	(b)	38.0*	192.42 (50.83)	69.04 (18.22)	26.5E-4	3.891
NP-0004	11.5 (28.3)	40(a)	3.5	99.19 (26.20)	39.68 (10.48)	1.4E-4	0.204
NP-0005	8.5 (20.9)	(b)	20.3*	73.25 (19.35)	22.33 (5.89)	4.5E-4	0.668
NP-0010	4.0 (10.0)	40(a)	7.3	35.05 (9.26)	14.02 (3.70)	1.0E-4	0.160
NP-0050, 51(c)	3.3 (8.1)	40(a)	2.7	28.39 (7.50)	11.36 (3.00)	0.3E-4	0.040
NP-1005	0.8 (2)	90(a)	1.9	7.01 (1.85)	6.31 (1.67)	0.01E-3	0.017
NP-0007	N/A	N/A	17.1	NA	146.89 (38.81)	2.51E-3	3.690
NP-1001	N/A	N/A	1.1	NA	32.23 (8.52)	0.04E-3	0.060
TOTAL	N/A	N/A	NA	644.51 (171.62)	412.20 (108.85)	6.49E-3	9.56

(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 34).
(b) Total runoff measured from flow meters.
(c) One outfall is monitored to represent both.
N/A Not Applicable.
Note: To convert from Ci/yr to Bq/yr, multiply Ci/yr by 3.7×10^{10}
* Flow-weighted average.

Table 7-6 Eight-Year Annual Average Uranium Concentrations at NPDES Outfalls

	ANNUAL AVERAGE TOTAL URANIUM (pCi/l)							
OUTFALL	1992	1993	1994	1995	1996	1997	1998	1999
NP-0001	516	1003*	1226*	(a)	(a)	(a)	(a)	(a)
NP-0002	228	230*	182*	124*	54*	14*	22*	8.0*
NP-0003	478	607*	332*	67*	88*	143*	83*	38.3*
NP-0004	6	9	12	(b)	(b)	(b)	23*	3.5
NP-0005	296	133*	347*	128*	107*	19*	10*	20.3*
NP-0010	--	--	82	107	50	2.7	10.7*	7.3
NP-0007	--	0.363	0.74	0.46	1.37	1.50	3.11	17.1
NP-1001	<0.0003	1.881	1.60	1.76	1.09	0.51	0.38	1.1
NP-1005	--	--	--	--	--	--	1.0(c)	1.9
NP-0050, 51(d)	--	--	--	--	--	--	--	2.7

* Flow weighted average.
-- Not applicable.
(a) Outfall removed, flow diverted to NP-0005.
(b) Outfall removed from permit in 1995, added in 1998.
(c) Outfall added in 1998.
(d) Outfall added in 1999.

increased at Outfalls NP-0005, NP-0007, and NP-1001 and decreased at Outfalls NP-0002, NP-0003, NP-0004, and NP-0010. The increases and decreases were all slight. Historical trending of uranium for Outfalls NP-0002, NP-0003, and NP-0005 is discussed in Section 11.1. Radium and thorium were both periodically monitored at Outfalls NP-0002, NP-0003, and NP-0005 throughout the year to monitor the effects and effectiveness of remediation. The parameters for each outfall are discussed in the succeeding paragraphs.

Outfall NP-0001 was the outlet of the abandoned process sewer outfall line. Outfall NP-0001 was physically eliminated during May 1994 and was officially eliminated from the permit on August 4, 1995.

The average uranium concentration for Outfall NP-0002 in 1999 was 8.0 pCi/l (0.30 Bq/l), a decrease from the 1998 average of 22.3 pCi/l (0.83 Bq/l). No radiological contaminants were detected above baseline values. Baseline values for contaminants in storm water were set before soil and foundation removal started. Baseline monitoring and values are discussed in Section 11.2. All levels were below the DCGs. Annual average NPDES results for Outfall NP-0002 are shown in Table 7-3.

The average uranium concentration for Outfall NP-0003 was 38.3 pCi/l (1.42 Bq/l), which was much less than the 1998 average of 83.1 pCi/l (1.42 Bq/l). The decrease may be the result of the controlled release of the runoff from Ash Pond, upstream remediation, and a drier than normal year. Ash Pond, before it was remediated during 1999, was used to store materials

removed from other areas of the site until they could be placed in the cell. Ash Pond was managed to avoid discharging water from the pond that was over 600 pCi/l. All values were well below the DCGs for radium and thorium. Annual average values for uranium, radium, thorium, gross alpha, and gross beta are shown in Table 7-3. There were three chromium levels that were above the baseline values but still well below the 100 µg/l notification level. There were six radiological levels above baseline values (one for Ra-226, four for Th-230, and one for Th-232) but they were all well below the DCGs for these contaminants. (Baseline values are discussed in Section 11.1.3.) One major contributor to NP-0003 was water from upstream of NP-0003 that flowed around Ash Pond in a diversion channel before entering Sedimentation Basin 4. Early in 1999 the diversion channel was routed to Ash Pond. After that, the Ash Pond water was analyzed for uranium to determine if the water required treatment or could be released to the surface. There was only one sample collected before the channel was routed to Ash Pond.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994, but was repermitted on May 22, 1998. The outfall was repermitted because a portion of Raffinate Pit 4 was remediated upstream of the outfall and storm water from the area flows to Outfall NP-0004. The annual average for uranium at NP-0004 was 3.5 pCi/l (0.13 Bq/l), much reduced from the 1998 annual average of 23.4 pCi/l (0.87 Bq/l). The reduction was most likely due to the area being remediated and vegetated. There was also less rainfall during 1999 than in 1998. One nitrate value was elevated, which caused the annual average to be elevated. Nitrate levels at NP-0004 are being closely watched. No other parameters were noted at elevated levels.

The annual average uranium concentration at Outfall NP-0005 for 1999 was 20.3 pCi/l (0.75 Bq/l), which is greater than the 1998 average of 10.0 pCi/l (0.37 Bq/l) but still much less than baseline and DCG levels. Annual average NPDES results are shown in Table 7-3, and baseline values are discussed in Section 11.2. The slight increase is attributed to natural variations or water that was diverted from the NP-0003 watershed to NP-0005 watershed.

Outfall NP-0010 was added to NPDES Permit MO-0107701 when it was reissued on March 4, 1994. This outfall is located near the west end of the north perimeter fence in the construction material staging area (CMSA), and drains a portion of the CMSA. The CMSA is used to store clean soil, gravel, and other construction material. Contaminated soil was removed and the CMSA was completed early in 1996. The annual average uranium concentration for 1999 was 7.3 pCi/l (0.27 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and slightly less than the 1998 average of 10.7 pCi/l (0.37 Bq/l). The slight decrease may be attributed to low precipitation levels during 1999. Radium and thorium were not suspected, and therefore, were not measured at NP-0010. The annual average NPDES results are reported in Table 7-3.

Ash Pond (SW-2010) was sampled quarterly, when water was flowing, for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232. Sampling was conducted to monitor the effects of demolition debris and soil stored in Ash Pond and remediation activities on Ash Pond runoff and subsequently, on the downstream outfall, NP-0003. The uranium average (based on the quarterly sampling) at Ash Pond was 119 pCi/l (4.4 Bq/l), much less than the 1998 average

of 464 pCi/l (17.2 Bq/l) and below the DCG of 600 pCi/l (22.2 Bq/l). The reduced uranium levels are likely the result of remediation of Ash Pond. Radium and thorium were measurable, but at levels well below the DCG. Table 7-7 contains the annual average radiological concentrations for location SW-2010.

Table 7-7 Ash Pond and Sedimentation Basin 1 - 1999 Annual Average Radiological Concentrations (pCi/l)

PARAMETER	ASH POND SW-2010	SEDIMENTATION BASIN 1 SW-2019
Ra-226	0.60	NS
Ra-228	1.54	NS
Th-228	0.17	NS
Th-230	0.53	NS
Th-232	0.09	NS
U-Total	119	11.1 (1 sample)
Gross alpha	152.1	NS
Gross beta	34.6	NS

NS Not Sampled.

The outlet of Sedimentation Basin 1 (SW-2019) was monitored only one time before the basin was converted to a retention basin and discharge ceased. Sedimentation Basin 1 discharged to the channel that leads to Outfall NP-0002 and made up most of the flow at NP-0002 before Frog Pond was remediated. After remediation, most flow bypassed Sedimentation Basin 1 and went directly to Outfall NP-0002. The sedimentation basin effluent was monitored to determine the contribution of the watershed flowing to the basin to NP-0002 uranium levels. The single measurement for uranium was 11.1 pCi/l (0.41 Bq/l), which is slightly above the NP-0002 average of 8.0 pCi/l (0.30 Bq/l). Table 7-7 contains the single sample result.

7.6.1.2 Physical and Chemical Results

Analytical results for physical and chemical (as opposed to radiochemical) parameters at NPDES outfalls and other sample locations are presented in Subsections 7.6.1.2.1 through 7.6.1.2.4.

7.6.1.2.1 Chemical Plant and Quarry Storm Water

The annual averages for the physical and chemical parameters for storm water Outfalls NP-0002, NP-0003, NP-0004, NP-0005, NP-0010, NP-0050, NP-0051, and NP-1005 are shown in Table 7-3. In addition to the permitted parameters, arsenic, chromium, lead, and thallium were periodically monitored at some outfalls. Some parameters were periodically present above baseline levels (see Section 11.1.3). There were also instances of metals that do not have permit

limits but were above the 100 µg/l reporting levels for toxic pollutants. These elevated levels were the result of greater than normal solids in the effluent.

Ash Pond (SW-2010) was sampled quarterly for polycyclic (or polynuclear) aromatic hydrocarbons (PAH), As, Cr, Pb, Tl, PCBs, 2,4-Dinitrotoluene (DNT), and 2,4,6-Trinitrotoluene (TNT) to monitor the effect of demolition debris and soils in Ash Pond, and the remediation of the Ash Pond area, on contaminants in the Ash Pond storm water runoff. Nitrate (as N) was also monitored. Analytical results are shown in Table 7-8. If contaminant concentrations had increased, then monitoring frequencies would have been increased. If increased monitoring were to indicate that Ash Pond water would cause contaminant levels at Outfall NP-0003 to exceed permit limits or reporting levels, than a valve in the Ash Pond discharge structure would be closed and the water retained.

There were two discharges from the chipped wood storage area during 1999. The chipped wood storage area pond (SW-2018) was sampled, and results received, before each discharge from the pond. All parameters were in compliance with the permitted limits. The results are not tabulated because they were all within permitted limits. Outfall NP-0003 results also reflect the contribution from the chipped wood storage area basin. The CWSA was remediated during March 1999 and this discharge was eliminated.

Table 7-8 Ash Pond - 1999 Annual Average Chemical Concentrations (µg/l)

PARAMETER	ASH POND (SW-2010)
PAHs	<10.2*
As	6.96
Cr	21.98
Tl	2.14
Pb	10.95
PCBs	<1.0*
2,4-DNT	0.19**
2,4,6-TNT	0.46**
Nitrate (as N)	54.2 mg/l

NS Not sampled
* All non-detect or at the detection limit.
** Three nondetects out of four samples.

7.6.1.2.2 Administration Building Sewage Treatment Plant

Monitoring results for the sewage treatment plant, Outfall NP-0006, are given in Table 7-9. Parameters were in compliance for the year, with only two minor discrepancies. The initial first quarter sample for total suspended solids exceeded the holding time for analysis. Another sample was collected, and the analysis was performed within the specified holding time.

The initial third quarter sample was in compliance for the weekly, but not the monthly, average for fecal coliform. Another sample was collected, and the fecal coliform was determined to be in compliance with the specified monthly average.

Table 7-9 NP-0006, Sewage Treatment Plant Outfall, Monthly Averages of Permitted Parameters

	PARAMETER (a) (PERMIT LIMITS)				
MONTH (QUARTER)	TSS (30/45 mg/l)*	BOD (30/45 mg/l)*	FC (b) (400/1000 col/100 ml)**	pH (6.0 – 9.0 SU)	TOTAL RESIDUAL CHLORINE (1.0/1.0 mg/l)**
February (1)	<5***	<20	<1	7.95	N.S.
February (1)	<5	N.S.	N.S.	N.S.	0.92
April (2)	3.0	5.5	326	6.96	0.22
July (3)	3.61	27	684	7.5	0.52
July (3)	N.S.	N.S.	<1	N.S.	N.S.
October (4)	6.0	<10	4	7.26	0.83

(a) One sample analysis required for each calendar quarter.
(b) F.C. – Fecal Coliform
* - Monthly average/Weekly average
** - Monthly average/daily maximum
*** - exceeded hold time

7.6.1.2.3 Site and Quarry Water Treatment Plant Physical and Chemical Parameters

Physical and chemical parameters, with the exception of one selenium result at the SWTP, were all within permitted limits (where limits were assigned) for the site and quarry water treatment plants. Since there was only one instance of a parameter being slightly above permitted limits, the parameter levels are not summarized here.

During 1999, WET tests were required quarterly for both the site and quarry water treatment plant effluent. Because the quarry water treatment plant was not in operation for one quarter of the year, there are only three sample results. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both Ceriodaphnia dubia (water flea) and Pimephales promelas (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No effluent samples failed the WET tests during 1999, indicating that the site and quarry water treatment plant effluents did not cause the receiving stream to be toxic to test organisms (see Table 7-2). Whole effluent toxicity test results are summarized in Table 7-10.

Table 7-10 1999 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants*

BATCH	DATE	DAPHNIA (D) % MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
S153	02/22/99	0	0	0,0	0,0
S161	05/01/99	0	0	0,0	0,0
S168	08/02/99	0	0	0,0	0,0
S177	11/01/99	0	0	0,0	0,0
Q055	06/22/99	0	0	0,0	0,2.5
Q056	07/07/99	0	0	0,0	0,0
Q062	10/07/99	0	2.5	0,0	0,2.5

S Site
Q Quarry
P Pimephales
D Daphnia (Ceriodaphnia)
* Each test is on four replicates of 10 organisms. % mortality is based on 40 organisms.

7.6.1.2.4 Hydrostatic Test Water Results

NPDES permit MO-G670203 was issued on December 5, 1997, for the discharge of hydrostatic test water. The permit requires that a sample be collected during the first 60 minutes of each discharge. The permit requires that flow, total petroleum hydrocarbons (TPH), TSS and pH be monitored. There is a daily maximum and monthly average for TSS and TPH; however, the monthly average and daily maximum are the same. The limit for TPH is 10 mg/l and for TSS 100 mg/l. The pH is limited to a range of 6.0 to 9.0. The discharge monitoring report is required to be submitted annually with the report due October 28, 1999, for the period October 1, 1998, to September 31, 1999. During calendar year 1999, there were no discharges of hydrostatic test water.

7.6.1.2.5 Borrow Area Land Disturbance Results

NPDES permit MO-R100B69 was reissued on May 29, 1998, and has no specified monitoring or reporting requirements. The 1999 *Environmental Monitoring Plan* (Ref. 8), however, requires that settleable solids be monitored once every calendar quarter, and that oil and grease be monitored as indicated by operations at the facility. Settleable solids and oil and grease results are shown in Table 7-11. Settleable solids were all less than 0.1 ml/l/hr. Oil and grease were monitored three times at the NP-0040 outfall, which is the outfall from the vehicle maintenance area sedimentation basin, and two times from the east sedimentation basin. Results were all well below the 10 mg/l water quality standard for oil and grease.

Table 7-11 Borrow Area Settleable Solids (ml/l/hr) and Oil and Grease

DATE	LOCATIONS			
	NP-0040*		NP-0046**	
	SETTLEABLE SOLIDS	OIL AND GREASE	SETTLEABLE SOLIDS	OIL AND GREASE
1/18/99	<0.1	N.S.	<0.1	N.S.
2/19/99	N.S.	2.0	N.S.	N.S.
4/15/99	<0.1	1.72	<0.1	1.41
7/1/99	<0.1	3.47	<0.1	2.14
10/8/99	<0.1	1.96	No Flow	No Flow
12/6/99	N.S.	N.S.	<0.1	N.S.

* North Borrow Area sedimentation basin.
** East Borrow Area sedimentation basin.

7.6.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are presented in Subsections 7.6.2.1 and 7.6.2.2.

7.6.2.1 Weldon Spring Chemical Plant and Raffinate Pits

Average uranium levels at the off-site surface water locations were lower than the 1998 annual averages at all locations. This reflects the lower levels seen at the NPDES outfalls. Average annual uranium concentrations for surface water are shown in Table 7-12, along with the 1998 figures and the historic high for the location for comparison. Surface water locations are shown in Figure 7-1. Overall, the uranium levels at the downstream sampling locations, except for location SW-2005, have remained in the range of the 1998 results. Location SW-2005 is the outlet of Lake 36. During part of 1998, the lake was drained for remediation, making the water at the outlet undiluted by lake water and, thus, essentially Outfall NP-0002 water with some dilution. The lake was filling or full during 1999. Dilution in the lake, and the remediation of the lake and lake inlet, are reflected by the much lower average for 1999. The inlets to Lakes 35 and 36 were not sampled during 1999 because they essentially reflect the NPDES outfalls at the site. Location SW-2001, the location in Dardenne Creek just downstream of where Schote creek enters, was deleted for 1999 because the location became inaccessible. Location SW-2024, Schote Creek just upstream of where it joins Dardenne Creek, was added to replace SW-2001.

Table 7-12 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations*

LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2004	9.3 (10.8)	10.7 (13.8)	6.3 (7.9)	39 (1989)
SW-2005	7.0 (21.8)	7.7 (42.3)	6.0 (0.8)	53.7 (1996)
SW-2012	5.7 (7.8)	8.5 (8.6)	3.7 (6.0)	326 (1991)
SW-2016	1.3 (1.5)	2.2 (1.6)	0.6 (0.9)	7.8 (1994)
SW-2024	2.8 (NA)	5.3 (NA)	1.1 (NA)	NA

* 1998 results are given in parentheses.
Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: Four samples were collected from each location during the year.

7.6.2.2 Weldon Spring Quarry

The average total uranium values continue to indicate that the highest levels are found in the portion of the Femme Osage Slough down-gradient of the quarry (SW-1003, SW-1004 SW-1005 and SW-1010). The annual averages for the surface water locations are summarized in Table 7-13. The uranium levels in the Femme Osage Slough are within historical ranges. No new historic total uranium high concentrations were reported for quarry surface water during 1999.

Table 7-13 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Monitoring Locations*

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-1003	32.67 (29.76)	57.28 (32.55)	10.60 (25.68)	252 (1989)
SW-1004	40.10 (43.68)	65.95 (63.35)	14.04 (28.43)	362 (1991)[a]
SW-1005	18.40 (22.98)	28.17 (29.65)	12.42 (13.77)	116 (1991)
SW-1007	20.88 (10.88)	46.46 (14.97)	7.04 (7.56)	69 (1992)
SW-1009	12.81 (9.91)	21.97 (14.16)	6.13 (5.13)	28.6 (1991)
SW-1010	28.57 (26.92)	57.85 (28.46)	9.91 (25.38)	156 (1991)

* 1998 results given in parentheses
Note: 1 pCi/l = 0.037 Bq/l
(a) A sample collected during 1993 flood conditions, representing groundwater discharge to the surface, had a result of 4,000 pCi/l. This sample is not reported as the historic high since it represents groundwater, not surface water.

8. GROUNDWATER MONITORING

8.1 Highlights of the Groundwater Monitoring Program

The following are highlights of the 1999 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- With exception of the Frog Pond vicinity, contaminant levels generally remained within historic ranges at all chemical plant groundwater monitoring locations.

- New historic high concentrations of nitroaromatic compounds were recorded in groundwater monitoring locations in the vicinity of Frog Pond. These may be attributable to recent remedial action in Frog Pond. An enhanced monitoring schedule has been implemented at these locations in 2000.

- Groundwater detection monitoring for the disposal cell that was initiated in June 1998 continued in 1999.

- Monitoring results for Burgermeister Spring were within historical ranges. No new highs or lows were recorded, and no significant changes are apparent.

- Volatile organic compounds (VOC) trichloroethene and dichloroethene detected in groundwater in 1996 at the chemical plant continued to be under investigation during 1999 to determine the extent of contamination. The VOC concentrations decreased in monitoring wells nearest the raffinate pits and were essentially constant at locations south of the pits.

8.2 Program Overview

The groundwater monitoring and protection program at the Weldon Spring Site Remedial Action Project (WSSRAP) includes sampling and analysis of water collected from wells at the Weldon Spring Chemical Plant and raffinate pits, the Weldon Spring Quarry, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in the *WSSRAP Groundwater Protection Management Program Plan* (Ref. 14). The groundwater monitoring portion of the program is detailed in the *Environmental Monitoring Plan* (EMP) (Ref. 8).

Due to lithologic differences, including those geologic features that influence groundwater flow mechanics, and the geographical separation of the chemical plant and quarry areas, separate groundwater monitoring programs have been established for the two sites. Generalized geologic and hydrologic descriptions of the two sites are found in Section 1.3. A

generalized stratigraphic column for reference is provided in Figure 8-1, and hydrogeologic descriptions of lithologies monitored for the program are in Section 8.4.

8.3 Referenced Standards

Two references used to develop the criteria for the groundwater monitoring program are: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Water 1986* (Ref. 35), which is intended to protect public groundwater resources, and (2) the Missouri Drinking Water Standards (Ref. 36). These standards are mainly used for comparison of levels observed in the St. Charles County well field. Table 8-1 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP since the affected groundwater aquifer underlying the site does not represent a public drinking water supply as defined in 40 CFR, Part 141, Subpart A - General.

Table 8-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD	PARAMETER		LEVEL	REFERENCE STANDARD
Radio-chemical	Uranium total(a,c)	20 µg/l (13.6 pCi/l)	EPA	Metals	Fe(d)	300 µg/l	MDWS
	Gross alpha (adjusted) (c)	15 pCi/l	MDWS		Pb(e)	15 µg/l	MDNR
	Ra-226(b,c)	5 pCi/l	MDWS		Mn(d)	50 µg/l	MDWS
	Rn-222(a,c)	300 pCi/l	EPA		Hg(c)	2.0 µg/l	MDWS
Misc.	2,4-DNT(e)	0.11 µg/l	MDNR		Ni(c)	100 µg/l	MDWS
	TDS(d)	500 mg/l	MDWS		Se(c)	50 µg/l	MDWS
Metals	Sb(c)	6.0 µg/l	MDWS		Ag(d)	100 µg/l	MDWS
	As(c)	50 µg/l	MDWS		Zn(d)	5.0 mg/l	MDWS
	Ba(c)	2 mg/l	MDWS				
	Be(c)	4.0 µg/l	MDWS	Anions	Cl-(d)	250 mg/l	MDWS
	Cd(c)	5 µg/l	MDWS		F-(d)	2.0 mg/l	MDWS
	Cr(c)	100 µg/l	MDWS		NO3(c)	10 mg/l	MDWS
	Cu(d)	1.0 mg/l	MDWS		SO4(d)	250 mg/l	MDWS

(a) Proposed.
(b) Standard for combined Ra-226 and Ra-228.
(c) Primary maximum contaminant level.
(d) Secondary maximum contaminant level.
(e) Water Quality Standard for Groundwater.
EPA EPA Drinking Water Standards for Radionuclides.
MDNR Missouri Department of Natural Resources
MDWS Missouri Drinking Water Standard.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (FT.)(1)	LITHOLOGY	PHYSICAL CHARACTERISTICS	HYDROSTRATIGRAHIC UNIT
QUATERNARY	HOLOCENE	ALLUVIUM	0 - 120		GRAVELLY, SILTY LOAM.	ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS AND GLACIAL DRIFT (2)	10- 60	VARIABLE	SILTY CLAY, GRAVELLY CLAY, SILTY LOAM, OR LOAM OVER RESIDUUM FROM WEATHERED BEDROCK.	(UNSATURATED)(2)
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION (3)	0 - 15		LIMESTONE, LIMEY DOLOMITE, FINELY TO COARSELY CRYSTALINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE.	
		WARSAW FORMATION (3)	60 - 80		SHALE AND THIN TO MEDIUM BEDDED FINELY CRYSTALINE LIMESTONE WITH INTERBEDDED CHERT.	
	OSAGEAN	BURLINGTON AND KEOKUK LIMESTONES	100 - 200		CHERTY LIMESTONE, VERY FINE TO VERY COARSELY CRYSTALINE, FOSSILIFEROUS, THICKLY BEDDED TO MASSIVE.	SHALLOW AQUIFER SYSTEM
		FERN GLEN LIMESTONE	45 - 70		CHERTY LIMESTONE, DOLOMITIC IN PART, VERY FINE TO VERY COARSELY CRYSTALINE, MEDIUM TO THICKLY BEDDED.	
	KINDERHOOKIAN	CHOUTEAU LIMESTONE	20 - 50		DOLOMITIC, ARGILLACEOUS LIMESTONE; FINELY CRYSTALINE; THIN TO MEDIUM BEDDED.	UPPER LEAKY CONFINING UNIT
DEVONIAN	UPPER	SULPHUR SPRINGS GROUP BUSHBERG SANDSTONE (4)	40 - 55		QUARTZ ARERNITE, FINE TO MEDIUM GRAINED, FRIABLE.	
		LOWER PART OF SULPHUR SPRINGS GROUP UNDIFFERENTIATED			CALCAREOUS SILTSTONE, SANDSTONE, COLITIC LIMESTONE, AND HARD CARBONACEOUS SHALE.	
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE (5)	10 - 30		CALCAREOUS TO DOLOMITIC SILTY SHALE AND MUDSTONE, THINLY LAMINATED TO MASSIVE.	
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70 - 100		LIMESTONE, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, FOSSILIFEROUS AND CHERTY NEAR BASE.	MIDDLE AQUIFER SYSTEM
		DECORAH GROUP	30 - 60		SHALE WITH THIN INTERBEDS OF VERY FINELY CRYSTALINE LIMESTONE.	LOWER CONFINING UNIT
		PLATTIN LIMESTONE	100 - 130		DOLOMITIC LIMESTONE, VERY FINELY CRYSTALLINE, FOSSILIFEROUS, THINLY BEDDED.	
		JOACHIM DOLOMITE	80 - 105		INTERBEDDED VERY FINELY CRYSTALLINE, THINLY BEDDED DOLOMITE; LIMESTONE; AND SHALE. SANDY AT BASE.	
		ST. PETER SANDSTONE	120 - 150		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, MASSIVE.	DEEP AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	50 - 60		SANDY DOLOMITE, MEDIUM TO FINELY CRYSTALINE, MINOR CHERT AND SHALE.	
		COTTER DOLOMITE	200 - 250		ARGILLACEOUS, CHERTY DOLOMITE; FINE TO MEDIUM CRYSTALINE. INTERBEDDED WITH SHALE.	
		JEFFERSON CITY DOLOMITE	160 - 180		DOLOMITE, FINE TO MEDIUM CRYSTALINE.	
		ROUBIDOUX FORMATION	150 - 170		DOLOMITIC SANDSTONE.	
		GASCONADE DOLOMITE	250		CHERTY DOLOMITE AND ARENACEOUS DOLOMITE (GUNTER MEMBER).	
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		DOLOMITE, MEDIUM TO COARSELY CRYSTALLINE, MEDIUM BEDDED TO MASSIVE.	
		POTOSI DOLOMITE	100		DOLOMITE, FINE TO MEDIUM CRYSTALLINE, THICKLY BEDDED TO MASSIVE. DRUSY QUARTZ COMMON.	

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-GS02 AND GS05. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMMELL (REF 54). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-252-GI (REF 53).

(2) GLACIAL DRIFT UNIT SATURATED IN NORTHERN PORTION OF ORDNANCE WORKS WHERE THIS UNIT BEHAVES LOCALLY AS A LEAKY CONFINING UNIT. (GEOLOGIC LOG)

(3) THE WARSAW AND SALEM FORMATIONS ARE CONSIDERED TO BE ABSENT FROM THE WELDON SPRING AREA DUE TO EROSION.

(4) THE SULPHUR SPRINGS GROUP ALSO INCLUDES THE BACHELOR SANDSTONE AND THE GLEN PARK LIMESTONE-MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY. (REF 53)

(5) THE MAQUOKETA SHALE IS NOT PRESENT IN THE WELDON SPRING AREA BASED ON GEOLOGIC LOGS.

GENERALIZED STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 8-1

REPORT NO.	EXHIBIT NO.
DOE/OR/21548-845	A/PI/047/0391

ORIGINATOR	DRAWN BY	DATE
MET	SRS	4/21/00

Groundwater is also monitored under the requirements of Department of Energy Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water equivalent to 100 mrem (1.0 mSv) effective dose equivalent, based on the consumption of 730 liters/year (193 gal/year) (Table 8-2). As specified in Department of Energy Order 5400.5, liquid effluent from U.S. Department of Energy (DOE) activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem (0.04 mSv/year) per year or 4% of the DCG.

Table 8-2 Derived Concentration Guidelines for Discharge Waters

PARAMETER	DERIVED CONCENTRATION GUIDELINE
Natural Uranium	600 pCi/l
Ra-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

Note: 1 pCi/l = 0.037 Bq/l.

8.4 Weldon Spring Chemical Plant

8.4.1 Hydrogeologic Description

The Weldon Spring Chemical Plant is located in a physiographic transitional area between the Dissected Till Plains of the central lowlands province to the north and the Salem Plateau of the Ozark Plateaus province to the south.

The chemical plant is located on a groundwater divide from which groundwater flows north toward Dardenne Creek and then ultimately to the Mississippi River, or south to the Missouri River. Regional groundwater flow for St. Charles County is towards the east. Localized flow is controlled largely by topographic highs and streams and drainages. Groundwater movement is generally by diffuse flow with localized zones of discrete fracture-controlled flow.

The chemical plant and raffinate pit area lithologies consist of two major geologic units; unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated. Thicknesses range from 6.1 m to 15.3 m (20 ft to 50 ft) (Ref. 2).

Potential groundwater impacts are assessed by monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the chemical plant, raffinate

pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit). The Burlington-Keokuk Limestone is composed of two different lithologic zones, a shallow weathered zone underlain by an unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be found on a limited scale in the unweathered zone. The unweathered portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Localized aquifer properties are controlled by fracture spacing, solution voids, and preglacial weathering, including structural troughs along the bedrock-unconsolidated material interface.

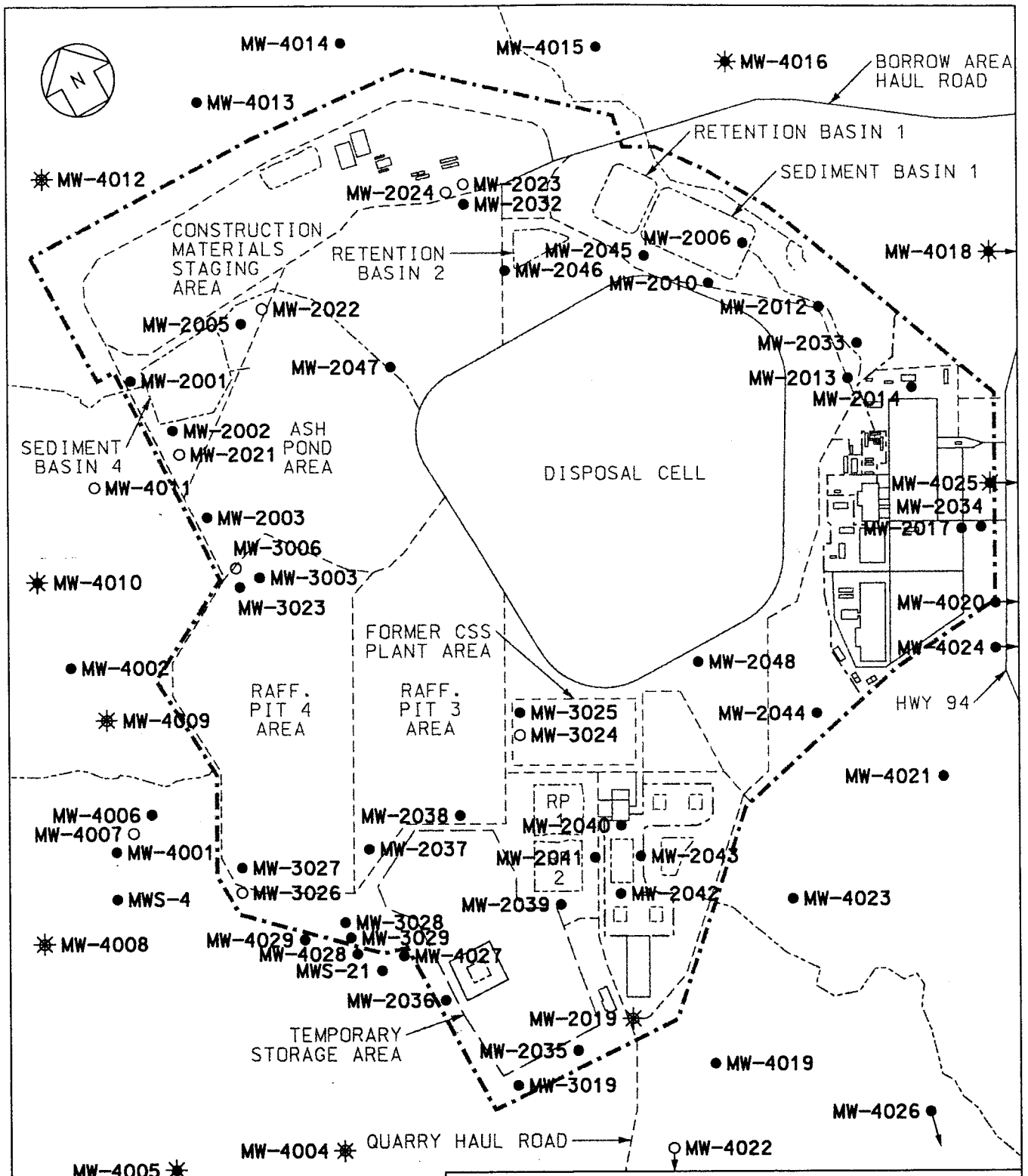
More than 100 monitoring wells have been used for groundwater observations and sampling since 1987. Many of these have been deactivated and abandoned. Thirteen wells were abandoned during 1999. Active monitoring was performed in 43 wells in 1999.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Some wells that are screened in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. The majority of the wells are completed in the weathered unit of the bedrock where groundwater has the greatest potential for contaminant impact. Where possible, monitoring wells within the boundaries of the chemical plant are located close to potential contaminant sources to assess migration into the groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 8-2).

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it straddles the regional groundwater divide. Background values for uranium, nitrate, and sulfate were developed by the U.S. Geological Survey (USGS) for the shallow aquifer and are used in lieu of these comparisons (Ref. 37).

Springs, a common feature in carbonate terrains, are present in the vicinity of the Weldon Spring site. Four springs are known to have been historically influenced by chemical plant discharge water potentially containing one or more of the contaminants of concern (Figure 8-3). Currently, Burgermeister Spring (SP-6301 on Figure 8-3) is monitored to determine contaminant off-site migration potential via spring transport.

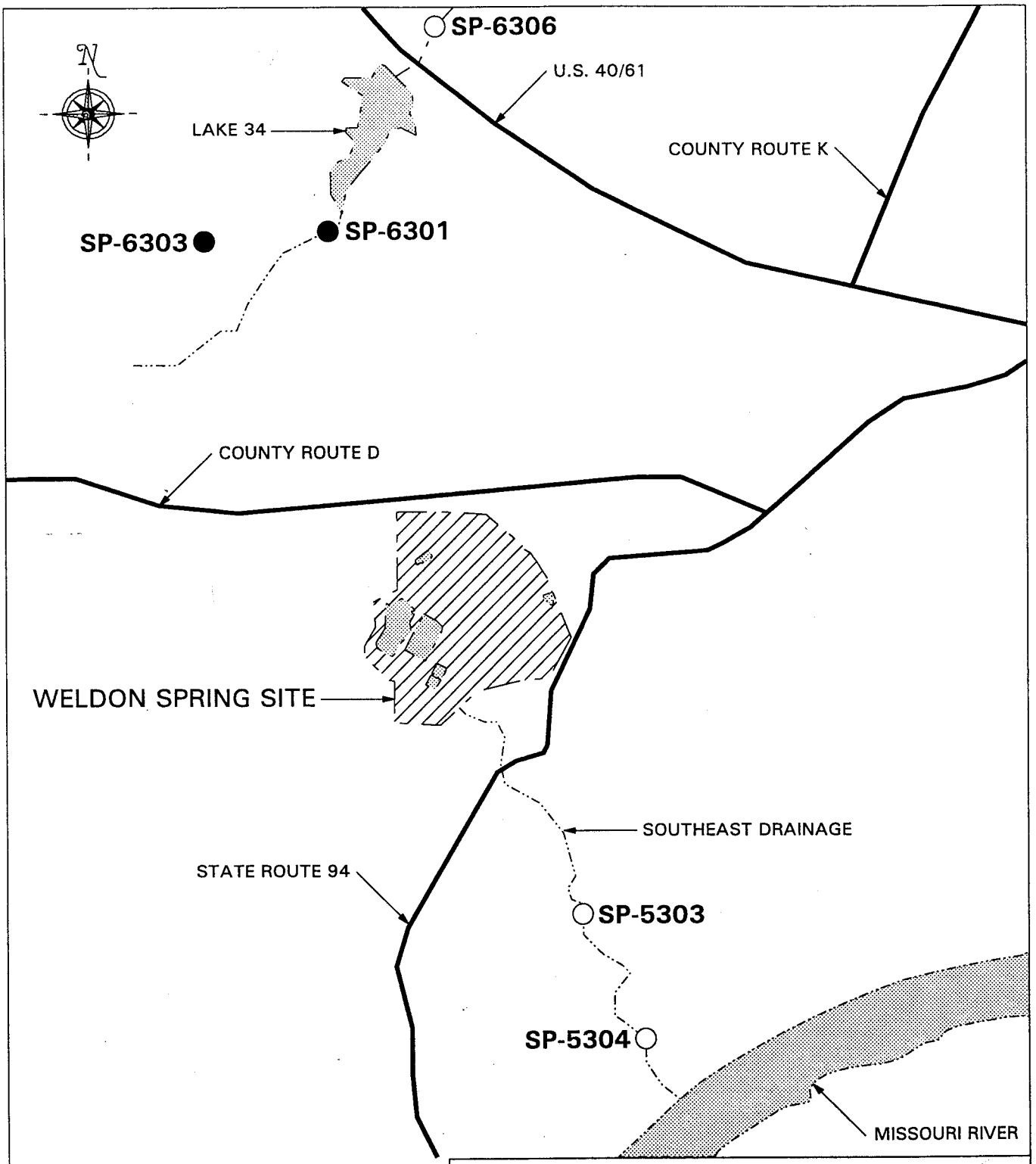
The presence of elevated total uranium and nitrate levels at Burgermeister Spring, which is located 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site. Groundwater tracer tests performed in 1995 (Ref. 54) indicate that a discrete and rapid hydraulic connection between the WSSRAP and Burgermeister Spring exists.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT MONITORING WELL NETWORK

FIGURE 8-2

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/CP/077/1295		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	5/22/00



LEGEND

● - SPRING SAMPLE LOCATION

○ - OTHER SAMPLE LOCATION

NOT TO SCALE

SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA

FIGURE 8-3

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/080/1193		
ORIGINATOR:	BWD	DRAWN BY:	GLN	DATE:	4/21/00

8.4.2 Monitoring Program

The 1999 groundwater monitoring program at the chemical plant and raffinate pits focused on monitoring known contaminants and determining any groundwater impacts which may have resulted from remedial action (e.g., soil excavation and sludge removal) at the site. A summary of monitoring locations and parameters may be found in the *1999 Environmental Monitoring Plan* (EMP) (Ref. 8). The EMP includes provisions for initiation of special environmental studies if evidence or conditions arise that warrant investigation beyond the scope of the EMP sampling schedule.

Total uranium, nitroaromatic compounds, sulfate, volatile organic compounds, and nitrate were monitored annually at selected locations. Total uranium in groundwater was analyzed under the environmental monitoring program at the chemical plant to monitor potential groundwater uranium migration and to further establish baseline uranium concentrations prior to source removal during remedial action. Due to the heterogeneity of uranium distribution in soils across the site, all active locations in the chemical plant groundwater monitoring network were analyzed for total uranium. Analytical results for all monitored parameters are summarized and discussed in Section 8.4.3.

Groundwater in the vicinity of the raffinate pits is impacted with elevated nitrate concentrations. The pits contained ore-refining wastes from uranium ore concentrates that were digested with nitric acid during the original chemical plant operations. Some of the wastes generated and disposed of as raffinate contained isotopes of thorium and radium. Therefore, groundwater samples from selected locations near the raffinate pits have historically been analyzed for nitrate, thorium, and radium isotopes, and total uranium. Enhanced monitoring (initiated during 1997) designed to detect groundwater contaminant impact resulting from raffinate pit remediation efforts continued through 1999. The enhanced program included bimonthly monitoring for nitrate, sulfate, metals, and uranium at 13 locations in the vicinity of the raffinate pits.

Prior to construction of the chemical plant, the site was part of a Department of Army Ordnance Works complex developed for the production of the nitroaromatic compounds trinitrotoluene (TNT) and dinitrotoluene (DNT) for explosives. One of the first nitroaromatic production lines was located within what is now the chemical plant area perimeter. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits which released contaminated seepage to groundwater. Wastewater containing nitroaromatic compounds was transported through wooden pipe networks. Discrete locations at the chemical plant are known (from previous sampling) to be impacted with nitroaromatics. Those locations, which were previously determined to have detectable concentrations of nitroaromatics in groundwater, were sampled and analyzed for these compounds in 1999.

Historic high nitroaromatic data for samples obtained in the vicinity of Frog Pond during 1999 led to enhanced monitoring. Quarterly sampling was initiated during the second half of the

year at wells near Frog Pond. The additional data will be used to more closely track the groundwater impacts of remediation activities in this area, which had historically been the site of TNT and DNT production process.

Elevated levels of uranium detected in the vicinity of Ash Pond during 1998 led to enhanced monitoring in 1999. Monthly sampling was initiated at six locations near Ash Pond to assess the effect of remediation activities in this area on uranium concentrations in the underlying groundwater.

The volatile organic compound (VOC) trichloroethene (TCE) was detected in groundwater south and east of Raffinate Pits 3 and 4 during 1996. VOC monitoring was conducted bimonthly at selected wells during 1999 to determine lateral and vertical extents of the TCE, assess the mobility of the contaminant, and evaluate the effect of remediation activities on VOC contamination levels.

Groundwater moves by both diffuse and discrete flow components under the chemical plant. In order to monitor the discrete flow component, Burgermeister Spring was monitored during 1999 for total uranium, nitroaromatic compounds, volatile organic compounds, nitrate, sulfate, and geochemical parameters. The spring was sampled during high- and base-flow conditions to monitor the potential impacts to the spring recharge from surface water runoff in the vicinity of the chemical plant. Three other springs located along drainages that flow away from the site were sampled quarterly for volatile organic compounds during base-flow conditions.

8.4.3 Chemical Plant Monitoring Results

8.4.3.1 Groundwater Monitoring Wells

Monitoring data for contaminants of concern (e.g., uranium, radiological parameters, nitrate, sulfate, volatile organic compounds, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs. Data values are presented as reported by the analytical laboratories. Comparisons to drinking water standards are for reference purposes only, and are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards.

Uranium. Total uranium, which is measured at all monitoring wells, continues to impact groundwater near the raffinate pits. In 1999, groundwater from nine monitoring well locations exceeded the average background level of 2.9 pCi/l (0.11 Bq/l) calculated by the USGS (Ref. 37). These values are shown in Table 8-3. A new historic high for uranium was recorded during 1999 at MW-3024 (64.3 pCi/l or 2.38 Bq/l). This monitoring well was damaged in early 1997 and restoration included drilling out the casing and screen to facilitate installation of new well construction materials. Elevated uranium values above the proposed MCL standard have been detected in this location since the well repair completion. Further repairs to this well are

anticipated in 2000 to ensure that the seal above the well screen is properly set.

New historic high values of total uranium were reported for two other locations. These wells, MW-2041 and MW-3025, are located in the general proximity of MW-3024. The elevated levels of uranium are likely due to the remediation activities in the area of the raffinate pits.

Table 8-3 Annual Averages for Total Uranium (pCi/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (pCi/l)	NUMBER OF SAMPLES
MW-2017	6.42	1
MW-2041	5.64	4
MW-2042	2.91	4
MW-3003	13.03	6
MW-3023	8.15	6
MW-3024	59.42*	5
MW-3025	2.97	5
MW-4020	12.3	1
MW-4022	3.83	1

* Concentration exceeds proposed EPA maximum contaminant level of 20 µg/l (13.6 pCi/l).
Note 1: Background uranium concentration equals 2.9 pCi/l.
Note 2: 1 pCi/l = 0.037 Bq/l.

Radiological Parameters. The other radiological parameters (Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta) that are measured annually in the raffinate pit wells (MW-3000 series) and in the waste storage facility wells were within historic values. These annual averages are presented in Table 8-4 for all wells where at least one parameter was present above the detection limit.

Table 8-4 Annual Radiological Isotope Activities (pCi/l) at the Weldon Spring Chemical Plant

	AVERAGE CONCENTRATION (pCi/l)						
LOCATION	Ra-226	Ra-228	Th-228	Th-230	Th-232	GROSS ALPHA	GROSS BETA
MW-2032	0.18	0.25	0.06	0.19	0.04	NA	NA
MW-2035	0.29	0.05	<0.05	0.54	0.07	NA	NA
MW-2036	0.38	0.29	<0.02	0.18	0.01	NA	NA
MW-2037	0.05	0.07	0.01	0.05	<0.01	NA	NA
MW-2038	0.14	<0.37	0.02	0.01	<0.01	NA	NA
MW-2039	0.16	0.15	0.01	0.03	0.01	NA	NA
MW-2040	<0.04	0.13	<0.04	0.14	<0.01	NA	NA
MW-2041	0.51	0.28	<0.02	0.19	0.01	NA	NA
MW-2042	0.23	0.13	0.01	0.16	0.01	NA	NA
MW-2043	0.20	0.18	0.02	0.20	<0.02	NA	NA
MW-2045	0.27	0.33	0.25	0.25	0.04	NA	NA
MW-2046	0.08	0.24	0.06	0.12	0.02	NA	NA
MW-2047	0.20	0.53	0.17	0.19	0.01	NA	NA
MW-2048	0.19	0.36	0.04	0.04	0.02	NA	NA
MW-3003	0.17	0.39	0.17	0.15	0.06	18.0	35.9
MW-3023	0.96	0.50	<0.01	0.04	0.01	9.33	27.5
MW-3024	0.20	0.13	0.08	0.19	0.04	15.9	20.9
MW-3025	0.09	0.04	0.08	0.16	0.10	6.13	20.1
MW-3026	0.23	0.35	0.26	0.37	0.24	9.83	47.9
MW-3027	0.24	0.24	0.09	0.35	0.03	2.29	2.65
MW-4028	0.25	0.27	0.03	0.08	<0.04	6.29	32.3

< Average concentration was less than the highest detection limit.
NA Not Analyzed

Nitrate and Sulfate. In 1999, nitrate and/or sulfate were measured at 30 monitoring wells in the chemical plant area that previously exceeded the reference levels. Nitrate levels exceeded the Missouri drinking water standard (10 mg/l) at 22 of those locations (see Table 8-5). Average sulfate levels exceeded background (32 mg/l) as determined by the USGS (Ref. 37) at eight locations. None of the sulfate data were above the Missouri drinking water standard (250 mg/l) (see Table 8-6).

Nitroaromatic Compounds Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 26 monitoring wells (Table 8-7). New historic highs were reported during 1999 at several wells in the vicinity of Frog Pond, most notably at MW-2012. Levels of nitroaromatics have increased at this well since 1997, which is most likely a result of remedial activities in this area.

Table 8-5 Annual Values of Nitrate (mg/l) Levels Exceeding Drinking Water Quality Standard at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	SAMPLE POPULATION
MW-2001	93	1
MW-2002	167	1
MW-2003	336	1
MW-2005	88	1
MW-2037	332	7
MW-2038	1,115[a]	6
MW-2039	72	7
MW-2040	142	4
MW-2041	162	4
MW-2047	61	5
MW-3003	377	6
MW-3023	159[b]	6
MW-3024	343	5
MW-3025	297	5
MW-3026	162	6
MW-3027	31	6
MW-4001	49	6
MW-4006	37[c]	6
MW-4011	139	2
MW-4027	18	1
MW-4028	349	6
MW-4029	516	1

(a) This value includes a historic high of 2,230 mg/l, which is almost twice as high as the next highest value. When this value is disregarded, the average concentration is 892 mg/l.

(b) This value includes a historic low of 12.5 mg/l, which is more than 10 times lower than the other data collected in 1999. When this value is disregarded, the average concentration is 188 mg/l.

(c) This value includes a historic high of 164 mg/l, which is more than 10 times higher than the other data collected in 1999. When this value is disregarded, the average concentration is 11.4 mg/l.

Note : Missouri drinking water standard designates the primary maximum contaminant level as 10 mg/l.

Table 8-6 Annual Values of Sulfate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	SAMPLE POPULATION
MW-2037	108	7
MW-2038	39	6
MW-2041	37	4
MW-2042	39	4
MW-2046	49	5
MW-2048	249	5
MW-4028	87	1
MW-4029	118	1

Note : Background sulfate concentration equals 32 mg/l. Missouri drinking water standard designates the secondary maximum contaminant level as 250 mg/l.

The drinking water standard for 2,4-DNT of 0.11 µg/l was equaled or exceeded in 16 locations at the chemical plant (see Table 8-7). Elevated nitroaromatics in groundwater underlying the site are attributable to wastewater impoundments and production lines used in the production of TNT and DNT during the 1940s.

Table 8-7 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of a Nitroaromatic Compound (µg/l) at the Weldon Spring Chemical Plant

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2001	0.068	0.021	<0.030	0.050	0.054	<0.030
MW-2002	0.014	0.026	0.004	0.045	0.26	<0.030
MW-2003	0.014	<0.090	<0.030	0.11	0.53	<0.030
MW-2005	0.030	0.057	<0.030	0.046	0.11	<0.030
MW-2006	6.25	0.056	<0.030	0.125	1.15	0.058
MW-2012	68.33	0.47	163.3	643.3	610.0	0.01
MW-2013	4.75	<0.090	0.40	0.16	1.8	<0.030
MW-2014	2.9	0.07	<0.030	0.15	0.55	0.01
MW-2032	0.04	<0.090	0.09	0.06	0.10	<0.030
MW-2033	4.0	0.031	0.61	0.15	1.2	<0.030
MW-2037	<0.030	<0.090	<0.030	0.20	0.04	<0.030
MW-2038	0.09	<0.090	<0.030	0.68	0.12	0.12
MW-2043	<0.030	<0.090	<0.030	0.08	<0.010	<0.030
MW-2045	0.04	0.14	<0.030	0.13	0.64	<0.030
MW-2046	3.126	0.14	2.66	0.17	8.58	<0.030
MW-2047	0.03	<0.090	<0.030	0.34	0.51	<0.030
MW-3003	<0.030	<0.090	<0.030	0.13	0.16	<0.030
MW-3023	<0.030	<0.090	<0.030	0.35	1.3	<0.030
MW-3025	<0.030	<0.090	<0.030	0.11	0.16	<0.030
MW-3026	0.064	<0.090	<0.030	0.036	0.026	<0.030
MW-3027	0.073	<0.090	<0.030	0.033	0.029	<0.030
MW-4001	45.0	<0.090	2.1	0.13	1.9	<0.030
MW-4006	12.0	<0.090	<0.030	0.076	2.2	<0.030
MW-4011	<0.030	<0.090	0.051	<0.030	0.071	<0.030
MW-4015	5.4	<0.090	<0.030	0.077	0.78	<0.030
MW-4028	0.58	0.11	0.02	0.20	0.19	<0.030

Volatile Organic Compounds. The VOC groundwater investigation was initiated during 1996 when dewatering activities in Raffinate Pit 4 exposed approximately 2,000 previously submerged drums of waste. Whether the wastes from the drums impacted groundwater remains uncertain, due to the small quantity of pre-1996 groundwater data for VOCs from monitoring wells in the vicinity of Raffinate Pits 3 and 4. Due to the limited areal extent of groundwater impact and low concentrations of TCE degradation products, it is possible that the VOC introduction to groundwater is a recent event that may be a response to remedial action in Raffinate Pit 4 or sludge dredging in Raffinate Pit 3.

TCE monitoring continued through 1999 in order to monitor the extent of contamination

and changes in concentration that may have resulted from remedial activities. The 1999 analytical results for all wells with detectable levels of TCE are summarized in Table 8-8. Results are presented for two different analytical test methods, as indicated.

Table 8-8 Annual Average TCE (μg/l) Analytical Results

	TCE (by EPA CLP OR 8260B)		TCE (by EPA 8260)	
LOCATION	AVERAGE	(N)	AVERAGE	(N)
MW-2013	1.78	6	1.39	6
MW-2037	817	8	NA	NA
MW-2038	107	6	NA	NA
MW-3025	9.86	5	9.06	5
MW-4001	5.4	6	4.87	6
MW-4027	3.09	6	2.67	6
MW-4028	545	6	535	6
MW-4029	574	6	544	6
MW-S004	<10	6	0.83	6
MW-S021	144	6	141	6

(N) Sample population
NA Not analyzed

Metals. Seven locations were monitored for metals (TCLP metals) as part of the enhanced groundwater monitoring in the vicinity of the raffinate pits, and 14 locations were monitored as part of the waste facilities management program. The 1999 data from these locations were compared to historical metals data to assess groundwater impacts resulting from site remediation. No substantially elevated metals data were reported during 1999 for this enhanced monitoring program.

Groundwater Overview. With few exceptions, contaminant levels generally remained within historical ranges at the monitoring wells sampled under the environmental monitoring program. Select 1999 chemical plant locations were trended and are discussed in Section 8.4.4. Uranium, sulfate, and nitrate contamination continues to be concentrated in the area surrounding the raffinate pits with a small area of elevated uranium located near the eastern boundary of the site. Discrete areas of nitroaromatic contaminated groundwater continue to be present in the vicinity of Frog Pond, along the northern perimeter of the site, near Raffinate Pit 4, and west of the raffinate pits on the Weldon Spring Ordnance Works property. The source of VOC contamination south and east of Raffinate Pit 3 remains under investigation.

8.4.3.2 Springs

Springs located in Valley 6300 and Valley 5300 were monitored in accordance with the 1999 environmental monitoring program. Burgermeister Spring (SP-6301) is a perennial spring and is a localized emergence of groundwater impacted by a recognizable contribution of

contaminants from the chemical plant throughout the year, with the highest concentrations of contaminants occurring during base flow stages. During high flow conditions, surface water recharge along the path of the subsurface flow mixes with contaminated flow from the site, and the concentrations are effectively lowered. This spring (SP-6301) was monitored during both high and base stages during 1999.

Burgermeister Spring samples for uranium, nitrate, and sulfate were within expected (i.e., historical) ranges during 1999. Sampling results for these parameters are presented in Table 8-9. Nitroaromatic compounds were analyzed in samples from base stage flow only, and the compounds 2,4,6-TNT; 2,4-DNT; and 2,6-DNT were reported above detection limits. These results are presented in Table 8-9 also.

Monitoring of Burgermeister Spring will continue for the duration of the project to determine whether remediation activities across the northern half of the chemical plant impact the local groundwater quality.

Table 8-9 1999 Monitoring Data for Burgermeister Spring

	HIGH FLOW				LOW (BASE) FLOW			
PARAMETER	MIN.	MAX.	AVG.	(n)	MIN.	MAX.	AVG.	(n)
Nitrate (mg/l)	3.55	14.5	9.02	2	2.28	17.6	11.1	7
Sulfate (mg/l)	35.9	47.9	41.9	2	32.5	52.8	46.8	7
U-Total (pCi/l)	30.7	64.2	47.4	2	30.2	82.1	68.2	7
2,4,6-TNT	NS	NS	NS	0	0.029	0.031	0.03	5
2,4-DNT	NS	NS	NS	0	0.040	0.05	0.04	5
2,6-DNT	NS	NS	NS	0	0.20	0.24	0.23	5

(n) Sample population
NS Not sampled.

VOCs were monitored quarterly at SP-5303, SP-5304, SP-6301, and SP-6303 during 1999 to assess the potential for off-site migration of TCE that was detected in groundwater in the vicinity of the raffinate pits. These locations were sampled during base flow conditions, which are predominated by groundwater flow. No TCE concentrations were reported above detection limits at any of these locations in 1999.

8.4.4 **Trend Analysis**

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. Results of the TREND analyses indicate the potential presence of statistically-significant trends, as well as, their direction and magnitude. The trend testing output data are to be interpreted as screening indicators based on existing cumulative data. Results of the analyses are not intended to be used for the prediction of future

concentrations, but they may be used to indicate areas that should be more closely monitored in the future.

8.4.4.1 Statistical Methods

The TREND program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution (such as a normal or lognormal distribution). The nonparametric method used in this program is valid for scenarios where there are a high number of non-detect data points. Data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller than the smallest measured value in the data set (i.e., one-half the specified quantitation limit). This approach is valid since only the relative magnitudes of the data, rather than their measured values, are used in the method. The TREND program was also used in past analyses of the site groundwater data. Thus, use of the TREND program offered the advantage of maintaining continuity in the analysis methodology.

The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. In this approach, a test statistic, Z, is calculated. A positive value of Z indicates an upward trend. Likewise, a negative value of Z indicates a downward trend. The alpha value (or error limit) selected for testing was 0.05. In the two-tailed test at the 0.05 alpha level of significance, the null hypothesis of "no trend" was rejected if the absolute value of the Z statistic was greater than Z_1-$\alpha/2$, where Z_1-$\alpha/2$ was obtained from a cumulative normal distribution table. In other words, the absolute value of the TREND output statistic, Z was compared to the table $Z_{.975}$ value of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

The linear slope of the trend was estimated for all data sets in which an upward or downward trend was identified. The slope was estimated using a nonparametric procedure included in the computer code for the TREND program. A 95% two-sided confidence interval about the true slope was calculated to indicate the variability of the values upon which the trend line was based. The direction and slope of the trend, along with the upper and lower 95% confidence limit estimates, are included in the summary tables at the end of this section.

One-half the specified quantitation limit (on the date of analysis) was used in the trend analysis for all data reported as below the detection limit. The purpose of using one-half the quantitation limit for non-detect data was to minimize the potential bias of the data. However, a consequence of this approach may be that, in some instances, the results may have been impacted by quantitation limits changing over time. The effect of varying quantitation limits is more likely to impact the trending analysis in instances where a large number of non-detect data are present within a given time series. The summary tables include the total number of data observations and the total number of non-detect data points for each data set so that this factor may be considered.

In cases where both filtered and unfiltered samples were collected for uranium analysis, the unfiltered sample data were used in the trend analysis. Filtered sample data are typically used only for evaluating whether a particular parameter (e.g., metals) exceeds baseline conditions established under the detection monitoring program at one of the on-site waste treatment facilities. (Baseline levels are based on 1993 to 1994 data collected from filtered samples.) For trending purposes, the unfiltered sample data are used because the 1995 to 1999 data are based predominantly on unfiltered samples.

Graphs presenting the contaminant concentration versus time for each contaminant per trending location were developed. These graphs were used to identify suspect data outliers only for each trending analysis and are not presented in this report. No statistical tests were conducted for suspect outliers. Data that were suspect were flagged and rechecked for potential data transcription errors. No obvious errors were identified.

8.4.4.2 Chemical Plant Trend Results

The selected wells from the chemical plant were trended for nitrate, trichloroethene, and nitroaromatic compounds. The cumulative results for the time period 1995 through 1999 were evaluated using the TREND program and are summarized below. The above wells were not previously trended for these analytes, thus no comparisons to past trend results can be made:

Nitrate

Fourteen locations near the chemical plant were selected for nitrate trend analyses. These locations consisted of both weathered and unweathered bedrock wells in the chemical plant and raffinate pit areas.

Nitrate trends for 1995-1999 data are stationary at five locations, as shown in Table 8-10. Nitrate trends are upward for the following four wells: MW-2037, MW-2038, MW-2039, and MW-4001. Nitrate trends are downward for the following five wells: MW-2032, MW-3024, MW-3025, MW-3026, and MW-3027.

Three of the 14 locations that were evaluated have reported 1999 concentrations that exceed all past 1995, 1996, 1997, and 1998 data for their respective sampling locations. These nitrate levels are 402.00 mg/l at MW-2037; 2,230.00 mg/l at MW-2038; and 164.00 mg/l at MW-4006. The 1999 new high concentrations for these locations are presented in the far right column of Table 8-10.

Table 8-10 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary

Well ID	Location	No. of Observations 1995-1999	No. of Non-Detect Data 1995-1999	Trend Direction (Alpha = 0.5) 1995-1999	Slope (mg/L/yr) 1995-1999	95% Upper & Lower Confidence Intervals on Slope (mg/L/yr) 1995-1999	1999 New High Concentration (mg/L) 1995 to Date
MW2032[a]	Weathered bedrock Northern Chemical Plant	12	0	D	-12.238	-39.024, -4.325	No
MW2037	Weathered bedrock, Raffinate Pit Area	30	0	U	17.667	8.000, 29.000	402.00
MW2038	Weathered bedrock, Raffinate Pit Area	30	0	U[c]	35.000[c]	10.350, 67.718[c]	2230.00[c]
MW2039	Weathered bedrock, Raffinate Pit Area	28	0	U	9.750	6.599, 13.001	No
MW2040	Weathered bedrock, Raffinate Pit Area	20	0	S	-10.000	-18.410, -0.881	No
MW3003	Weathered bedrock, Raffinate Pit Area	21	0	S	2.750	-8.869, 15.000	No
MW3023	Weathered bedrock, Raffinate Pit Area	19	0	S	5.500[d]	-10.000, 22.796[d]	No
MW3024	Weathered bedrock, Raffinate Pit Area	18	0	D	-19.250	-28.277, -2.973	No
MW3025[a]	Unweathered bedrock, Raffinate Pit Area	20	0	D	-51.000	-74.783, -21.433	No
MW3026	Weathered bedrock, Raffinate Pit Area	13	0	D	-10.000	-14.759, -6.500	No
MW3027	Unweathered bedrock, Raffinate Pit Area	22	0	D	-7.300	-8.540, -6.550	No
MW4001[a]	Weathered bedrock West of Chemical Plant	19	0	U	3.325	1.835, 5.115	No
MW4006[b]	Weathered bedrock West of Chemical Plant	14	0	S	-3.950[e]	-5.365, 2.822[e]	164.00[e]
MW4011	Unweathered bedrock West of Chemical Plant	7	0	S	-3.500	-14.493, 34.733	No

D = Downward S = Stationary U = Upward

(a) Data from 1996 are not available for wells MW2032, MW3025, and MW4001.

(b) Data from 1996 and 1998 are not available for well MW4006.

(c) These results are based on data that includes a one-time historic high concentration (2,230 mg/l) that is almost twice as high as any other historic data.

(d) The historic low for MW-2023 was not included in the trend analysis because it was almost 10 times lower than any other historic data.

(e) The historic high for MW-4006 was not included in the trend analysis because it was almost 10 times higher than any other historic data.

Trichloroethene

Six locations near the chemical plant were selected for trichloroethene trend analyses. Five of these locations are weathered bedrock wells, and one is an unweathered bedrock well.

Trichloroethene trends for 1995-1999 data were stationary at two locations and downward at the remaining four, as shown in Table 8-11. The wells showing a downward trend are MW-2037, MW-2038, MW-3025, and MWSO21.

None of the six locations evaluated have reported 1999 concentrations that exceed all past 1995, 1996, 1997, and 1998 data for the specific sampling location.

Nitroaromatic Compounds

Seven locations near the chemical plant were selected for trend analyses of nitroaromatic compounds. All seven of these locations are weathered bedrock wells.

The results of the nitroaromatic compounds analyses for the monitoring wells near the chemical plant are presented in Table 8-12. Each of these locations was trended for the following nitroaromatic compounds: 2,4-DNT, 2,6-DNT, 2,4,6-TNT, and 1,3,5-trinitrobenzene (1,3,5-TNB). In total, 28 trend analyses were performed on the nitroaromatic compounds at the seven groundwater monitoring well locations.

Upward trends were indicated for each of four nitroaromatic compounds at one location, MW-2012. No other upward trends were identified. Downward trends were indicated for all four nitroaromatic compounds at MW-2032 and for 2,6-DNT at MW-2033 and MW-4001. All other results of the trend analyses indicated stationary trends.

As shown in Table 8-12, all four nitroaromatic compounds at MW-2012 and 2,6-DNT at MW-2014 have reported concentrations in 1999 that exceed all past 1995, 1996, 1997, and 1998 data for their respective sampling locations. The new highs for MW-2012 are the following: 690.00 µg/l for 2,4-DNT; 640.00 µg/l for 2,6-DNT; 78.00 µg/l for 1,3,5-TNB; and 180.00 µg/l for 2,4,6-TNT. The new high for 2,6-DNT at MW-2014 is 0.69 µg/l.

8.5 Weldon Spring Quarry

8.5.1 Hydrogeologic Description

The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 1). Three Ordovician-age formations comprise the bedrock at the quarry: The Kimmswick Limestone, the

Table 8-11 Chemical Plant Groundwater Wells Trichloroethene Trend Analysis Summary

Well ID	Location	No. of Observations 1996-1999	No. of Non-Detect Data 1996-1999	Trend Direction (Alpha = 0.5) 1996-1999	Slope (µg/l/yr) 1996-1999	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1996-1999	1999 New High Concentration (µg/l) 1996 to Date
MW2037	Weathered bedrock, Raffinate Pit Area	25	0	D	-146.667	-240.000, -49.019	No
MW2038	Weathered bedrock, Raffinate Pit Area	25	0	D	-281.917	-323.604, -238.358	No
MW3025	Unweathered bedrock, Raffinate Pit Area	23	1	D	-7.275	-15.081, -2.919	No
MW4001	Weathered bedrock West of Chemical Plant	24	3	S	0.020	0.000, 0.190	No
MWS004[a]	Weathered bedrock, Raffinate Pit Area	23	20	S	0.000	0.000, 0.000	No
MWS021[a]	Weathered bedrock, Raffinate Pit Area	23	1	D	-239.000	-306.209, -136.439	No

D = Downward
S = Stationary

Data were not available for 1995 for any of the wells.
(a) Data for 1996 were not available for wells MWS004 and MWS021.

Table 8-12 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary

Well ID	Location	Compound	No. of Observations 1995-1999	No. of Non-Detect Data 1995-1999	Trend Direction (Alpha = 0.5) 1995-1999	Slope (µg/l/yr) 1995-1999	95% Upper & Lower Confidence Intervals on Slope (ug/L/yr) 1995-1999	1999 New High Concentration (µg/L) 1995 to Date
MW2006	Weathered bedrock – Frog Pond	2,4-DNT	7	1	S	0.008	-0.005, 0.030	No
		2,6-DNT	7	1	S	0.000	-0.050, 0.287	No
		1,3,5-TNB	6	1	S	0.200	-0.375, 2.654	No
		2,4,6-TNT	7	7	(a)	(a)	(a)	No
MW2012	Weathered bedrock - Frog Pond	2,4-DNT	8	0	U	172.475	0.623, 297.266	690.00
		2,6-DNT	8	0	U	154.864	5.775, 240.159	640.00
		1,3,5-TNB	8	0	U	17.542	1.973, 29.727	78.00
		2,4,6-TNT	8	0	U	44.036	10.156, 66.584	180.00
MW2013	Weathered bedrock - Frog Pond	2,4-DNT	7	0	S	-0.047	-0.072, -0.002	No
		2,6-DNT	7	0	S	-0.500	-0.790, -0.010	No
		1,3,5-TNB	7	0	S	-0.300	-0.857, 0.270	No
		2,4,6-TNT	7	0	S	-0.107	-0.149, 0.014	No
MW2014	Weathered bedrock - Frog Pond	2,4-DNT	7	0	S	0.000	-0.007, 0.003	No
		2,6-DNT	7	0	S	0.000	-0.040, 0.063	0.69
		1,3,5-TNB	6	0	S	0.100	-0.768, 0.490	No
		2,4,6-TNT	7	5	S	-0.006	-0.009, 0.000	No
MW2032	Weathered bedrock - Northern Chemical Plant	2,4-DNT	12	0	D	-0.027	-0.057, 0.011	No
		2,6-DNT	12	0	D	-0.896	-1.402, 0.408	No
		1,3,5-TNB	12	1	D	-1.146	-1.621, 0.333	No
		2,4,6-TNT	12	0	D	-1.958	-3.131, 0.698	No
MW2033	Weathered bedrock - Frog Pond	2,4-DNT	7	0	S	-0.098	-0.157, 0.009	No
		2,6-DNT	7	0	D	-0.600	-1.121, -0.079	No
		1,3,5-TNB	7	0	S	-0.125	-0.866, 0.678	No
		2,4,6-TNT	7	0	S	-0.145	-0.316, 0.100	No
MW4001	Weathered bedrock - West of Chemical Plant	2,4-DNT	6	0	S	-0.086	-0.422, 0.004	No
		2,6-DNT	6	0	D	-0.300	-0.515, -0.170	No
		1,3,5-TNB	6	0	S	3.417	-7.450, 12.450	No
		2,4,6-TNT	6	0	S	0.183	-0.084, 0.323	No

D = Downward
S = Stationary
U = Upward

2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
2,4,6-TNT	2,4,6-Trinitrotoluene
1,3,5-TNB	1,3,5-Trinitrobenzene

(a) No or only one detectable concentration reported for time period; therefore, no trending performed.

limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium along the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 31 m (100 ft). The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations) which also composes the rim wall of the quarry. The bedrock unit underlying the alluvial materials north of the Femme Osage Slough is the Decorah Group. Primary sediments between the bluff and the Femme Osage Slough are inorganic and organic intermixed and interlayered clays, silts, and sands with some organics.

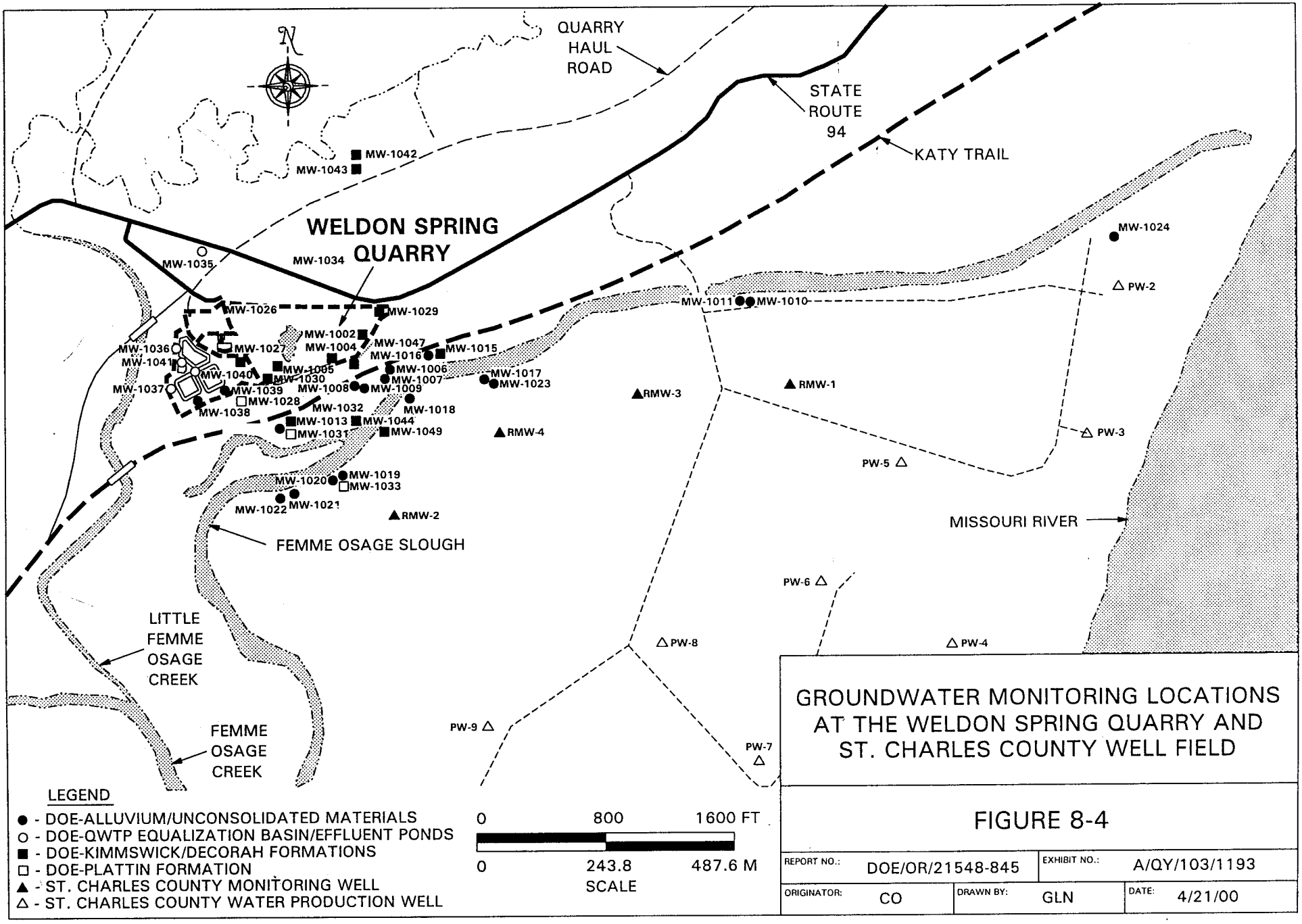
The uppermost groundwater flow systems at the quarry are composed of alluvial and bedrock aquifers. The alluvial aquifer is predominantly controlled by recharge from the Missouri River and the bedrock aquifer is chiefly recharged by precipitation and overland runoff.

At the quarry, 20 monitoring wells are screened within either the Kimmswick-Decorah (upper unit) or Plattin Formations (lower unit) to monitor contaminants near the quarry within the bedrock (Figure 8-4). Twelve monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. Six other monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration. Two monitoring wells, one in the Kimmswick-Decorah Formation and one in the Plattin Formation, were installed north of the quarry to monitor upgradient groundwater quality.

There are 36 monitoring wells completed into the alluvium at the quarry and the Missouri River. The wells west of the quarry monitor the uppermost water bearing unit below the quarry water treatment plant equalization basin and effluent ponds. The alluvium monitoring wells north of the Femme Osage Slough monitor contaminant migration south of the quarry, while those south of the slough monitor for possible migration of contaminants toward the well field. The St. Charles County monitoring wells, the RMW series wells, are designed to provide an early warning of contaminant migration toward the county production well field. The county production wells are monitored to verify the quality of the municipal well field water supply. Eight groundwater monitoring wells located in the Darst Bottom area approximately 1.6 km (1 mi) southwest of the St. Charles County well field are utilized to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the quarry. These wells provide a reference for background values in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). A summary of background values used at the quarry is provided in Table 8-13 (Ref. 55).

8.5.2 Monitoring Program

Groundwater monitoring is performed in both the alluvial and bedrock aquifers at the quarry (Figure 8-4). Three separate monitoring programs were employed for the quarry in 1999.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD

FIGURE 8-4

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/QY/103/1193		
ORIGINATOR:	CO	DRAWN BY:	GLN	DATE:	4/21/00

Table 8-13 Average Background Values (pCi/l) for Quarry Monitoring Locations

PARAMETER	ALLUVIUM [a]	KIMMSWICK/DECORAH[b]	PLATTIN [c]
Total Uranium (pCi/l)	2.77	3.41	12.30
Ra-226 (pCi/l)	0.61	0.41	3.01
Ra-228 (pCi/l)	2.15	1.06	2.95
Th-228 (pCi/l)	0.33	0.33	4.25
Th-230 (pCi/l)	1.59	0.61	11.20
Th-232 (pCi/l)	0.28	0.38	3.02
Gross Alpha (pCi/l)	4.32	15.80	NA
Gross Beta (pCi/l)	6.82	19.30	NA
Nitroaromatics (µg/l)	NA	NA	NA
Arsenic (µg/l)	5.15	1.48	10.90
Barium (µg/l)	463.00	147.00	109.00
Sulfate (mg/l)	44.20	95.90	165.00

(a) Darst Bottom Wells (USGS and DOE)
(b) MW-1034 and MW-1043 (DOE)
(c) MW-1042 (DOE)
NA Not analyzed

The first program addressed sampling the Department of Energy wells and monitoring the quarry area to determine contaminant migration and the effects of quarry dewatering and bulk waste removal, which began in mid-1993 and were completed in late-1995. The frequency of sampling for each location was based on the distance of the well from the source or migration pathway. In 1999, monitoring wells on the quarry rim were sampled quarterly for total uranium, due to the changes in concentrations over time, to better establish the trend in concentrations at these locations, and to monitor the effects of quarry dewatering and bulk waste removal activities on the groundwater system. All locations were sampled at least annually for radiochemical parameters nitroaromatic compounds, and sulfate.

The second program monitors the St. Charles County well field and the associated water treatment plant. Active production wells, the St. Charles County RMW-series monitoring wells, and untreated and treated water from the County's public drinking water treatment plant were sampled quarterly or semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State regulatory agencies, and St. Charles County.

The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 8-4). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was initially developed to meet the substantive requirements of 40 CFR Part 264, Subpart F, and 10 CSR Part 25.7, which require the monitoring of contaminants of concern in the groundwater beneath storage facilities. The contaminants of concern were derived from the *Engineering Evaluation/Cost Analysis for the*

Proposed Management of Contaminated Water in the Weldon Spring Quarry (Ref. 38) and the *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 39).

8.5.3 Weldon Spring Quarry Monitoring Results

8.5.3.1 Quarry

Radiochemical Parameters. Groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, and isotopic thorium. The uranium values continue to indicate that the highest levels occur in the bedrock downgradient from the quarry and in the alluvial material north of the Femme Osage Slough. The 1999 annual averages for the locations that exceed background are summarized in Table 8-14.

Table 8-14 Annual Averages for Total Uranium (pCi/l) Above Background at the Weldon Spring Quarry

LOCATION	AVERAGE	(n)	BACKGROUND VALUE
MW-1002	4.50	1	3.41
MW-1004	1800.00	1	3.41
MW-1005	1350.00	1	3.41
MW-1006	2280.00	1	2.77
MW-1007	6.13	1	2.77
MW-1008	2740.00	1	2.77
MW-1013	464.00	1	3.41
MW-1014	557.00	1	2.77
MW-1015	236.00	1	3.41
MW-1016	90.70	1	2.77
MW-1027	151.00	1	3.41
MW-1030	20.10	1	3.41
MW-1031	96.80	1	12.30
MW-1032	167.00	1	3.41
MW-1038	2.80	1	2.77
MW-1044	0.34	1	2.77
MW-1046	152.00	1	12.30
MW-1048	582.00	1	12.30

NOTE: 1 pCi/l = 0.037 Bq/l
(n) Sample population.

The proposed U.S. Environmental Protection Agency total uranium drinking water standard of 20 µg/l (13.6 pCi/l or 0.5 Bq/l) (40 CFR 192.02) was exceeded at MW-1004, MW-1005, MW-1006, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, MW-1032, MW-1046, and MW-1048. All of these monitoring wells are located north of the Femme Osage Slough and have no direct impact on the drinking water

sources in the Missouri River alluvium. The proposed standard, while used as a reference level, is not applicable to groundwater north of the slough because it is not considered a usable groundwater source.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed at all groundwater monitoring locations at the quarry. The 1999 annual averages for the locations that exceed background are summarized in Table 8-15.

Table 8-15 Annual Averages for Isotopic Radionuclides (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	Ra-226	(n)	Ra-228	(n)	Th-228	(n)	Th-230	(n)	Th-232	(n)
MW-1002	0.54	1	-	1	-	1	-	1	-	1
MW-1004	0.77	1	-	1	-	1	-	1	-	1
MW-1005	2.71	1	1.23	1	-	1	-	1	-	1
MW-1007	1.01	1	-	1	-	1	-	1	-	1
MW-1009	0.72	1	-	1	-	1	-	1	-	1
MW-1010	0.64	1	-	1	-	1	-	1	-	1
MW-1013	0.62	1	1.70	1	-	1	0.69	1	-	1
MW-1015	0.45	2	-	2	-	2	-	2	-	2
MW-1017	0.64	2	-	2	-	2	-	2	-	2
MW-1018	0.64	1	-	1	-	1	-	1	-	1
MW-1019	1.55	1	-	1	-	1	-	1	-	1
MW-1021	1.16	1	-	1	-	1	-	1	-	1
MW-1023	2.12	2	2.49	2	-	2	-	2	0.30	2
MW-1027	0.64	1	-	1	-	1	-	1	-	1
MW-1034	0.50	1	-	1	-	1	-	1	-	1
MW-1035	2.24	1	-	1	-	1	-	1	-	1
MW-1036	0.74	1	-	1	-	1	-	1	-	1
MW-1037	-	1	-	1	0.41	1	-	1	0.41	1
MW-1039	0.64	1	-	1	-	1	-	1	-	1
MW-1049	0.76	1	-	1	-	1	-	1	-	1

NOTE: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
- Did not exceed average background.

Nitroaromatic Compounds. In 1999, samples from quarry monitoring wells were analyzed for nitroaromatic compounds. These monitoring wells, which have historically been impacted with nitroaromatics, are situated in the alluvial materials or bedrock downgradient of the quarry and north of the Femme Osage Slough. Significant decreases in nitroaromatic compounds were observed in samples from quarry rim bedrock wells during 1998 and 1999. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for all locations where at least one nitroaromatic compound was measured above the detection limit is provided in Table 8-16.

Table 8-16 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of Nitroaromatic Compound (μg/l) at the Weldon Spring Quarry

LOCATION	1,3,5-TNB	(n)	1,3-DNB	(n)	2,4,6-TNT	(n)	2,4-DNT	(n)	2,6-DNT	(n)	NB	(n)
MW-1002	10.50	2	0.09	2	3.05	2	0.05	2	3.75	2	<0.03	2
MW-1004	0.38	2	<0.09	2	0.87	2	0.07	2	0.24	2	<0.03	2
MW-1005	<0.03	2	<0.09	2	<0.03	2	<0.03	2	0.18	2	<0.03	2
MW-1006	6.60	2	<0.09	2	0.61	2	0.08	2	0.37	2	<0.03	2
MW-1015	2.00	2	0.14	2	0.94	2	0.04	2	0.17	2	<0.03	2
MW-1016	0.08	2	<0.09	2	0.05	2	<0.03	2	0.02	3	<0.03	2
MW-1027	<0.03	2	<0.09	2	1.03	2	1.13	2	1.43	2	<0.03	2

< All samples less than highest detection limit.
(n) Sample population.

Sulfate. Groundwater analyses in 1999 indicated sulfate levels were elevated in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials north of the Femme Osage Slough. The annual averages for these wells are summarized in Table 8-17.

Table 8-17 Annual Averages for Sulfate (mg/l) Above Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	(n)	BACKGROUND VALUE
MW-1005	190.00	1	95.90
MW-1006	87.75	2	44.20
MW-1008	99.00	2	44.20
MW-1009	65.10	2	44.20
MW-1014	94.45	2	44.20
MW-1015	106.00	2	95.90
MW-1016	104.50	2	44.20
MW-1029	113.50	2	95.90
MW-1032	174.50	2	95.90
MW-1035	50.95	4	44.20
MW-1036	59.80	4	44.20
MW-1037	326.25*	4	44.20
MW-1038	175.00	1	44.20
MW-1039	131.00	1	44.20
MW-1040	175.00	4	44.20
MW-1041	55.30	4	44.20

* Exceeds secondary MCL of 250 mg/l.
(n) Sample population

8.5.3.2 St. Charles County Well Field

Radiochemical Parameters. The St. Charles County production wells and the RMW-series monitoring wells were sampled semiannually during 1999 for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, gross beta, and total uranium

were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 8-18. The annual averages for total uranium in the well field remain at background. No production well exceeded the proposed groundwater standard of 20 µg/l (13.6 pCi/l).

The St. Charles County production wells, the RMW-series wells, and pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were sampled quarterly for gross alpha and gross beta. The annual averages for these locations are within the statistical variation of background ranges for groundwater occurring in the Missouri River alluvium. The Missouri Drinking Water Standard of 15 pCi/l (0.555 Bq/l) for gross alpha was not exceeded at any of the production wells. The St. Charles County treatment plant finished waters were in compliance with the gross alpha level of 10 pCi/l as established in 40 CFR 141 and endorsed in Department of Energy Order 5400.5. The Missouri Drinking Water Standard of 5 pCi/l (0.185 Bq/l) for combined Ra-226 and Ra-228 was not exceeded at any of the St. Charles County production well locations. No water quality standards have been established for isotopic thorium in drinking water.

Nitroaromatic Compounds. The St. Charles County production wells and the RMW-series monitoring wells were sampled quarterly for six nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

Sulfate. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The 1999 annual averages for the well field are summarized in Table 8-19. The secondary MCL for sulfate is 250 mg/l; this standard was not exceeded at any location in the well field.

Metals. Arsenic and barium were the only metals monitored during 1999 at the St. Charles County well field. The primary MCL for arsenic (50 µg/l) was exceeded at location RMW-2. The MCL for barium (2,600 µg/l) was not exceeded at any location. None of the values for either metal exceeded their respective MCLs in samples from the public water supply wells or from the St. Charles County water treatment plant (see Table 8-19).

8.5.4 Trend Analysis

Statistical tests for time-dependent trends at the Weldon Spring Quarry were performed on historical data from select groundwater wells. Trending was performed on total uranium and nitroaromatic data collected from 1995 to 1999. Trend analyses were performed at specific monitoring locations based on historical data and knowledge of the quarry groundwater system. Total uranium trends were analyzed at locations down-gradient of bulk waste sources and in areas of possible impact south of the slough. Nitroaromatic compounds were analyzed for locations down-gradient of bulk waste sources.

Table 8-18 Summary of Annual Averages of Radiochemical Parameters (pCi/l) for the St. Charles County Well Field

LOCATION	TOTAL URANIUM		GROSS ALPHA		GROSS BETA		Ra-226		Ra-228		Th-228		Th-230		Th-232	
	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)
MW-1024	0.11	4	1.92	4	5.31	4	0.55	1	0.71	1	0.14	1	0.04	1	0.05	1
MW-RMW1	0.99	4	2.23	4	4.69	4	1.24	2	0.66	2	0.01	2	0.03	2	0.01	2
MW-RMW2	4.20	4	6.55	4	5.14	4	0.16	2	0.51	2	0.04	2	0.10	2	0.03	2
MW-RMW3	0.58	4	2.52	4	6.48	4	0.52	2	0.71	2	0.05	2	0.03	2	0.02	2
MW-RMW4	1.51	4	2.59	4	4.64	4	0.46	2	0.32	2	0.05	2	0.06	2	<0.06	2
MW-PW02	0.17	4	1.76	4	5.62	4	0.48	2	1.12	2	0.04	2	0.05	2	<0.02	2
MW-PW03	0.23	4	1.63	4	5.56	4	0.57	2	1.51	2	0.02	2	0.08	2	0.02	2
MW-PW04	0.11	4	1.41	4	6.76	4	0.31	2	0.92	2	0.03	2	0.05	2	0.01	2
MW-PW05	0.26	4	1.61	4	5.02	4	0.35	2	1.00	2	0.03	2	0.06	2	0.01	2
MW-PW06	0.24	4	1.56	4	4.96	4	0.56	2	0.94	2	0.02	2	0.02	2	<0.06	2
MW-PW07	0.11	4	2.16	4	5.22	4	0.70	2	1.25	2	0.02	2	0.04	2	0.02	2
MW-PW08	0.31	4	2.08	4	4.15	4	0.38	2	1.00	2	0.03	2	0.06	2	0.01	2
MW-PW09	0.35	4	1.66	4	3.61	4	0.25	2	1.29	2	0.08	2	0.05	2	<0.02	2
MW-RAWW	0.17	4	1.92	4	6.84	4	0.54	2	1.21	2	0.03	2	0.05	2	0.01	2
MW-FINW	0.14	4	0.98	4	4.12	4	0.34	2	0.35	2	0.02	2	0.03	2	0.01	2

Note 1: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
< All samples less than highest detection limit.

Table 8-19 Annual Averages for Sulfate (mg/l), Arsenic (μg/l), and Barium (μg/l) in the St. Charles County Well Field

LOCATION	SULFATE		ARSENIC		BARIUM	
	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
MW-1024	23.25	4	21.58	4	472.75	4
MW-RMW1	17.65	4	10.75	4	466.50	4
MW-RMW2	12.33	4	126.38	4	349.00	4
MW-RMW3	35.00	4	32.45	4	421.50	4
MW-RMW4	38.10	4	41.60	4	295.25	4
MW-PW02	115.90	2	<2.10	2	355.50	2
MW-PW03	115.15	2	<2.10	2	295.50	2
MW-PW04	123.15	2	<2.10	2	317.50	2
MW-PW05	81.10	2	<2.10	2	343.00	2
MW-PW06	96.40	2	<2.10	2	329.50	2
MW-PW07	77.25	2	<2.90	2	431.50	2
MW-PW08	44.10	2	2.15	2	469.50	2
MW-PW09	33.75	2	3.28	2	503.00	2
MW-RAWW	97.55	2	1.53	2	363.00	2
MW-FINW	99.20	2	<2.10	2	91.25	2

(n) Sample population.
< All samples less than highest detection limit.

The computer program TREND, previously described in detail in Section 8.4.4, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. The results of the TREND testing are shown in Tables 8-20 and 8-21.

8.5.4.1 Quarry Trend Results

The cumulative results for the time period 1995 through 1999 for each analyte that was evaluated using the TREND program are summarized below. Remedial actions that addressed contamination source areas at the quarry were completed in 1993. The trending results for the period 1995 through 1999 for the quarry area were also compared to past trending results performed in 1999 for the period 1995 through 1998. The results of these analyses are also summarized below by analyte.

Total Uranium

Seventeen locations near the quarry were selected for total uranium trend analyses. Of these locations, 11 are bedrock wells and six are alluvial wells. Total uranium trends for 1995-1999 data were stationary except for five locations as shown in Table 8-20. The one upward trend for total uranium is indicated based on the 1995 through 1999 data for MW-1002, a bedrock monitoring well on the east rim. This well was not trended last year so the current trend cannot be compared to previous analyses.

The recent data for MW-1032, previously reported as indicating an upward trend based on the 1995 through 1998 data, appear to indicate a change to a stationary trend.

MW-1014 is the one alluvial well with a downward trend. The previous data from 1995 through 1998 for MW-1014 indicated a stationary trend. The three other locations with downward trends are bedrock monitoring wells. The previous data for MW-1004 and MW-1027 also indicated downward trends, while the previous data for MW-1013 indicated a stationary trend.

One of the 17 locations that was evaluated for the 1995-1999 time frame has reported uranium concentrations in 1999 that exceed all past 1996 and 1998 data for the specific sampling location. This uranium level is 152.00 pCi/l at MW-1046. (Data for this well from 1995 were not available as the well was installed in 1996. Also, no 1997 data were available.) The 1999 new high concentration for this location is presented in the far right column of Table 8-20.

Nitroaromatic Compounds

Three locations near the quarry were selected for trend analyses of 2,4-DNT. Of these locations, two are bedrock wells and one is an alluvial well. The results of the 2,4-DNT analyses for the monitoring wells near the quarry are presented in Table 8-21. Based on the results of the analyses, no upward trends were identified in groundwater from the bedrock wells or the alluvial well that were analyzed from the 1995 to 1999 period. The results of the recent analyses are the same as was indicated in the tests conducted last year using the 1995 through 1998 data.

As shown in Table 8-21, none of the three locations that were evaluated for the 1995-1999 time frame have reported concentrations in 1999 that exceed all past 1995, 1996, 1997, and 1998 data for the specific sampling locations.

8.6 Waste Treatment Facilities

8.6.1 Monitoring Program

Groundwater monitoring wells have been placed around four waste management units: the quarry water treatment plant (QWTP) and site water treatment plant (SWTP) equalization basins, the temporary storage area (TSA), and the disposal cell (see Figures 8-2 and 8-4). These wells were installed to detect contaminants in the uppermost water units beneath these storage facilities in order to comply with the requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations performed and documented in the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 38), the *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 39), and the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 40).

Table 8-20 Quarry Groundwater Wells Uranium Trend Analysis Summary

Well ID	Location	No. of Observations 1995-1999	No. of Non-Detect Data 1995-1999	Trend Direction (Alpha = 0.5) 1995-1999	Slope (pCi/L/yr) 1995-1999	95% Upper & Lower Confidence Intervals on Slope (pCi/L/yr) 1995-1999	1999 New High Concentration (pCi/L) 1995 to Date
MW1002	Bedrock – East rim	14	0	U	0.600	0.315, 1.965	No
MW1004	Bedrock – South rim	13	0	D	-270.000	-406.078, -118.987	No
MW1005[a]	Bedrock – South rim	8	0	S	-210.000	-2332.134, 791.067	No
MW1006	Alluvium – North of slough	9	0	S	-187.500	-439.521, 102.082	No
MW1007	Alluvium – North of slough	9	0	S	-0.667	-16.410, 15.326	No
MW1008	Alluvium – North of slough	9	0	S	35.000	-745.655, 501.197	No
MW1009	Alluvium – North of slough	9	3	S	-0.553	-2.910, 2.192	No
MW1013	Bedrock – North of slough	9	0	D	-87.333	-152.491, -54.008	No
MW1014	Alluvium – North of slough	9	0	D	-120.000	-188.849, -29.873	No
MW1015	Bedrock – North of slough	9	0	S	-23.000	-48.423, 0.714	No
MW1016	Alluvium – North of slough	9	0	S	-18.325	-25.595, -3.287	No
MW1027	Bedrock – West of quarry	9	0	D	-69.750	-114.785, -30.573	No
MW1030	Bedrock – South rim	13	0	S	-7.900	-14.776, -0.970	No
MW1031	Bedrock – North of slough	11	0	S	10.000	-12.991, 38.627	No
MW1032	Bedrock – North of slough	11	0	S	125.000	-91.440, 277.216	No
MW1046[b]	Bedrock – North of slough	4	0	S	41.233	N too small, 30.897	152.00
MW1048[b]	Bedrock – North of slough	4	0	S	160.333	N too small, 56.986	No

D = Downward
S = Stationary
U = Upward

(a) Data from 1998 are not available for well MW1005.
(b) Data from 1997 are not available for wells MW1046 and MW1048. Also, these wells were installed in 1996 so no 1995 data exist.

Table 8-21 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary

Well ID	Location	Compound	No. of Observations 1995-1999	No. of Non-Detect Data 1995-1999	Trend Direction (Alpha = 0.5) 1995-1999	Slope (µg/l/yr) 1995-1999	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1995-1999	1999 New High Concentration (µg/l) 1995 to Date
MW-1002	Bedrock – East rim	2,4-DNT	28	0	D	-0.020	-0.026, -0.018	No
MW-1004	Bedrock - rim	2,4-DNT	28	0	D	-0.015	-0.020, -0.010	No
MW-1006	Alluvium – North of Slough	2,4-DNT	20	6	S	-0.032	-0.112, -0.010	No

D = Downward
S = Stationary
U = Upward

2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
2,4,6-TNT	2,4,6-Trinitrotoluene
1,3,5-TNB	1,3,5-Trinitrobenzene

The detection monitoring programs at the QWTP, SWTP, and TSA consist of quarterly sampling for the following parameters:

- Total uranium.
- Anions (nitrate, sulfate, chloride, and fluoride).
- Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver).
- Nitroaromatic compounds.

and annual sampling for the following parameters:

- Radiochemical parameters (Ra-226, Ra-228, Th-230, Th-232, U-234, and U-238).
- Polychlorinated biphenyls (PCBs).
- Polynuclear aromatic hydrocarbons (PAH).
- Pesticides (endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP Silvex).

The concentrations of constituents in the monitoring wells were compared with previously established baseline concentrations for each well. By definition, any exceedence of baseline was determined to be statistically significant, and triggered certain reporting requirements. These requirements involved evaluation of historical and analytical data and leachate volumes collected within the liners of the basins or storage unit to determine whether the integrity of the basin liners had been breached.

8.6.2 Site Water Treatment Plant and Temporary Storage Area Monitoring Results

Collection of baseline data for the wells surrounding the equalization basin for the site water treatment plant and the temporary storage area was completed in December 1994. The baseline dataset for each monitoring well was established with a minimum of eight samples collected on a quarterly basis. A summary of baseline data for wells MW-2035 through MW-2043 can be found in Table 8-22. Annual average concentrations are listed in Tables 8-23 and 8-24. Exceedences of baseline are summarized as follows:

Monitoring data collected during 1999 were compared to the baseline values to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

- Barium was elevated during all four quarters at MW-2039.
- Nitrate was elevated during two quarters at MW-2042.
- Sulfate was elevated during one quarter at MW-2043.

None of the above exceedences are believed to be attributable to operation of the waste management facilities because all parameters for which baselines were exceeded in 1999 were present in the existing groundwater contamination plume underlying this area. In addition,

leachate collection data show no consistent increases in volume that would indicate a breach in the liner system.

8.6.3 Quarry Water Treatment Plant Monitoring Results

Monitoring wells MW-1035 through MW-1039 were installed in 1991 to monitor the shallow groundwater in the vicinity of the quarry water treatment plant. In 1993, two additional monitoring wells, MW-1040 and MW-1041, were installed closer to the equalization basin to better monitor the waste storage unit. Baseline was established for these newer wells utilizing 1994 and 1995 quarterly data. Monitoring wells MW-1038 and MW-1039 were deleted from this monitoring program because they were located cross gradient from the equalization basin at a distance too far to adequately monitor the basin and are possibly downgradient of contaminant sources in the quarry.

The baseline parameters for each well are presented in Table 8-25, and the summary of 1999 detection monitoring results is presented in Table 8-26. Samples were also analyzed for nitroaromatic compounds, pesticides, and PCBs. The baselines and analytical results for these parameters are not shown in either table because they are not naturally occurring and have not been detected in the monitoring system.

The 1999 results of the comparison of the monitoring data to baseline indicated that no radiological parameter exceeded baseline during the year. Total uranium and metals levels were below baseline for all wells in the water treatment facility detection monitoring network. The ions chloride, fluoride, and sulfate were slightly elevated above baseline concentrations. These values are not believed to be attributable to any quarry operations. Ion values are similarly increasing at the upgradient monitoring locations.

Chloride baseline concentrations were exceeded in samples collected from monitoring wells MW-1035, MW-1036, and MW-1040. The sources of these excursions are unknown, but it is unlikely that the water treatment facility is contributing to the chloride concentrations because one of the wells, MW-1035, is hydraulically upgradient from the facility. Monitoring wells MW-1037 and MW-1041 do not exceed baseline and are located closer to the treatment facility than MW-1035. A potential source of chloride is the deicing agent applied to Missouri State Route 94, which is located along the northern perimeter upgradient of the quarry water treatment facility.

The remainder of the monitoring parameters remained within baseline for each well. No detectable concentrations of nitroaromatic compounds, PCBs, polycyclic (or polynuclear) aromatic hydrocarbons, or pesticides were reported for 1999.

Table 8-22 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic (µg/l)	2.25	2.09	1.82	5.77	2.43	4.12	4.35	3.41	2.10
Barium (µg/l)	107	333	250	563	240	962	347	590	344
Cadmium (µg/l)	3.91	3.89	3.67	3.67	6.98	4.04	4.20	3.80	3.79
Chromium (µg/l)	4.21	4.33	3.83	3.83	14.1	14.1	18.4	6.62	4.52
Lead (µg/l)	4.08	2.17	1.65	1.65	1.50	3.30	8.53	2.40	2.81
Mercury (µg/l)	0.14	0.14	3.40	4.37	0.15	0.12	0.59	0.13	0.15
Selenium (µg/l)	4.71	1.86	20.0	24.9	24.5	9.42	96.6	4.11	7.11
Silver (µg/l)	5.78	6.07	6.08	6.08	13.8	5.40	10.3	6.18	4.96
Uranium (pCi/l)	1.93	1.64	2.17	2.32	4.12	4.64	8.35	3.33	2.34
Nitrate (mg/l)	2.05	5.03	668	2271	117	455	2256	13.8	8.03
Sulfate (mg/l)	6.89	5.64	177	132	54.6	27.9	196	39.5	20.8
1,3,5-TNB (µg/l)	0.02[a]	0.02[a]	0.29	0.37	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]
TNT (µg/l)	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]
2,4-DNT (µg/l)	0.02[a]	0.02[a]	0.79	2.14	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.09
2,6-DNT (µg/l)	0.01[a]	0.01[a]	0.19	0.41	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]

Note: 1 pCi/l = 0.037 Bq/l.
(a) Value represents the detection limit.

Table 8-23 Summary of the 1999 Detection Monitoring Data for the Weldon Spring Site Temporary Storage Area Groundwater Wells

	MW-2035		MW-2036		MW-2037		MW-2038		MW-2039	
PARAMETER	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
Arsenic (µg/l)	1.09	4	<2.7	4	<2.4	6	<2.4	6	1.48	6
Barium (µg/l)	93.8	4	278	4	94	6	326	6	425	6
Cadmium (µg/l)	0l.7	4	<0.5	4	0.18	6	<0.3	6	<0.3	6
Chromium (µg/l)	1.22	4	1.26	4	0.73	6	0.96	6	7.28	6
Lead (µg/l)	0.74	4	0.74	4	0.84	6	1.44	6	1.16	6
Mercury (µg/l)	<0.10	4	<0.10	4	<0.12	6	<0.12	6	<0.12	6
Selenium (µg/l)	1.74	4	<2.9	4	2.39	6	10.7	6	4.55	6
Silver (µg/l)	<2.5	4	<2.5	4	0.61	6	0.68	6	0.64	6
Total Uranium (pCi/L)	0.38	4	0.67	4	1.04	6	1.66	6	2.47	6
Nitrate (mg/l)	0.54	4	1.76	4	332	7	1,115	6	71.9	7
Sulfate (mg/l)	1.84	4	3.96	4	108	7	38.5	6	26.7	7
1,3,5-TNB (µg/l)	<0.03	4	<0.03	4	<0.03	6	0.09	6	<0.03	6
2,4,6-TNT (µg/l)	<0.03	4	<0.03	4	<0.03	6	<0.04	6	<0.03	6
2,4-DNT (µg/l)	<0.03	4	<0.03	4	0.2	6	0.68	6	<0.03	6
2,6-DNT (µg/l)	<0.01	4	<0.01	4	0.04	6	0.12	6	<0.01	6

NOTE: 1 pCi/l = 0.037 Bq/l
(n) Sample population.
< All samples less than highest detection limit.

Table 8-24 Summary of the 1999 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant Groundwater Wells

	MW-2040		MW-2041		MW-2042		MW-2043	
PARAMETER	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
Arsenic (µg/l)	<2.7	4	<2.7	4	1.08	4	1.08	4
Barium (µg/l)	569	4	251	4	335	4	327	4
Cadmium (µg/l)	<0.36	4	<0.36	4	<0.36	4	<0.36	4
Chromium (µg/l)	5.9	4	1.47	4	2.05	4	1.48	4
Lead (µg/l)	<1.6	4	<1.6	4	0.94	4	<1.6	4
Mercury (µg/l)	<0.12	4	<0.12	4	<0.124	4	<0.12	4
Selenium (µg/l)	5.62	4	14.4	4	1.72	4	3.65	4
Silver (µg/l)	0.76	4	0.95	4	0.75	4	0.88	4
Total Uranium pCi/l)	2.29	4	5.64	4	2.92	4	1.75	4
Nitrate (mg/l)	143	4	163	4	5.72	4	6.8	4
Sulfate (mg/l)	10.4	4	37	4	38.7	4	14.7	4
1,3,5-TNB (µg/l)	<0.03	4	<0.03	4	<0.03	4	<0.03	4
2,4,6-TNT (µg/l)	<0.03	4	<0.03	4	<0.03	4	<0.03	4
2,4-DNT (µg/l)	<0.03	4	<0.03	4	<0.03	4	0.08	4
2,6-DNT (µg/l)	<0.01	4	<0.01	4	<0.01	4	<0.01	4

Note: 1 pCi/l = 0.037 Bq/l
(n) Sample population.
< All samples less than highest detection limit.

Table 8-25 Baseline for the Detection Monitoring System at the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	2.66	9.70	3.08	12.0	7.56
U-234 (pCi/l)	12.1	(a)	4.95	10.8	5.79
U-238 (pCi/l)	13.2	(a)	3.25	6.72	3.45
Ra-226 (pCi/l)	1.32	0.25	0.72	2.17	1.47
Ra-228 (pCi/l)	0.81	1.00	1.58	1.79	1.25
Th-230 (pCi/l)	1.23	2.94	0.48	0.88	1.41
Th-232 (pCi/l)	0.35	0.34	0.40	0.39	0.35
Chloride (mg/l)	6.82	102	11.8	16.0	8.34
Fluoride (mg/l)	0.28	0.18	0.71	0.12	0.26
Nitrate (mg/l)	0.37	0.32	0.82	0.28	0.32
Sulfate (mg/l)	70.0	82.0	55.5	186	52.8
Arsenic (µg/l)	6.09	4.71	5.50	9.83	6.64
Barium (µg/l)	315	351	752	330	553
Cadmium (µg/l)	3.18	3.61	3.44	3.96	3.67
Chromium (µg/l)	4.81	7.57	7.57	19.6	15.5
Lead (µg/l)	1.59	2.06	2.06	2.72	5.84
Mercury (µg/l)	0.18	0.20	0.17	0.42	0.58
Selenium (µg/l)	7.81	3.63	5.09	5.63	5.28
Silver (µg/l)	4.99	4.78	4.78	5.69	8.45

(a) No data available for determination of baseline.
Note: 1 pCi/l = 0.037 Bq/l.

Table 8-26 Summary of the 1999 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035		MW-1036		MW-1037		MW-1040		MW-1041	
	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
Uranium, Total (pCi/l)	0.58	4	7.83	4	1.07	4	8.95	4	5.93	4
U-234 (pCi/l)	0.47	1	3.35	1	0.98	1	5.55	1	2.56	1
U-235 (pCi/l)	<0.03	1	0.12	1	0.04	1	0.31	1	0.07	1
U-238 (pCi/l)	0.45	1	2.69	1	0.41	1	4.42	1	1.80	1
Ra-226 (pCi/l)	2.24	1	0.74	1	0.16	1	0.20	1	0.49	1
Ra-228 (pCi/l)	0.14	1	0.14	1	0.23	1	<0.664	1	0.43	1
Th-230 (pCi/l)	0.19	1	0.05	1	0.54	1	0.09	1	0.08	1
Th-232 (pCi/l)	0.24	1	<0.02	1	0.41	1	0.02	1	0.01	1
Chloride (mg/l)	29.93	4	108.75	4	2.78	4	24.23	1	6.23	4
Fluoride (mg/l)	0.20	4	0.29	4	0.38	4	0.17	4	0.17	4
Nitrate (mg/l)	0.05	4	0.03	3	0.58	4	0.04	4	0.05	4
Sulfate (mg/l)	50.95	4	59.80	4	326.25	4	175.00	4	55.30	4
Arsenic (µg/l)	<2.66	4	1.57	4	2.76	4	1.52	4	1.77	4
Barium (µg/l)	272.25	4	220.00	4	74.58	4	158.25	4	341.25	4
Cadmium (µg/l)	<0.34	4	<0.34	4	<0.34	4	<0.34	4	<0.34	4
Chromium (µg/l)	0.72	4	2.24	4	2.12	4	1.02	4	1.09	4
Lead (µg/l)	<1.50	4	<1.50	4	1.56	4	0.90	4	<1.50	4
Mercury (µg/l)	<0.12	4	<0.12	4	<0.12	4	<0.12	4	<0.12	4
Selenium (µg/l)	<3.90	4	<3.90	4	<2.80	4	<3.90	4	<3.90	4
Silver (µg/l)	<0.12	4	<1.10	4	<1.10	4	<1.10	4	<1.10	4

Note: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
< All samples less than highest detection limit.

8.6.4 Disposal Cell Groundwater Monitoring

In the *Record of Decision for the Chemical Plant Area of the Weldon Spring Site* (Ref. 9), substantive requirements of Federal and State hazardous and/or solid waste regulations have been identified as applicable or relevant and appropriate requirements (ARARs) for the selected remedy. 40 CFR 264, Subpart F, 10 CSR 25-7.264(2)(F), and 10 CSR 80-3.010(8) were identified as relevant and appropriate requirements for the disposal cell.

Groundwater monitoring requirements under the *Resource Conservation and Recovery Act* (RCRA) (40 CFR 264) specify that a monitoring system must consist of a sufficient number of wells installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of background water and provide detection of contamination. There is no set number of wells required under the RCRA, but the Missouri Sanitary Landfill regulations (10 CSR 80.3) specify a minimum of one upgradient and three downgradient wells.

Monitoring wells MW-2045 through MW-2048 (installed during 1996), and previously existing well MW-2032, comprise the disposal cell groundwater detection monitoring network. These detection monitoring wells were sampled quarterly during all of 1997 and early 1998 to provide baseline data. Semi-annual detection monitoring began in mid-1998, after waste placement activities were initiated. In accordance with 10 CSR 25-7.264(2)(F), a surface water component is also included in the detection monitoring program. Spring 6301 (Burgermeister Spring) has been identified as the appropriate downgradient location for surface water monitoring. Sampling of this spring will yield samples representative of the quality of surface water hydraulically downgradient of the disposal cell.

8.6.4.1 Baseline Conditions

Prior to waste placement, the disposal cell monitoring wells and SP-6301 were sampled on a quarterly basis for 1 year in order to establish baseline water quality conditions. A comprehensive list of parameters was analyzed at this time. Baseline conditions for each location were determined by generating an upper bound value for each parameter based on a 95% tolerance interval calculated for each data set.

The *Disposal Cell Groundwater Monitoring Plan* (Ref. 40) indicates that the analysis of variance (ANOVA) procedure was the preferred method for data comparisons between the upgradient well and the compliance wells. However, subsequent monitoring data results have shown that, due to the presence of preexisting groundwater contamination, such inter-well comparisons cannot be made. Instead, an intra-well comparison of baseline conditions with detection monitoring results will be performed using the tolerance interval approach. This method is an accepted alternative procedure, as discussed in the *Groundwater Monitoring Plan* (Ref. 40) and recommended in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance* (Ref. 41).

Table 8-27 presents the baseline values for each monitoring well in the cell well network and SP-6301. No baseline values are presented for volatiles, PCBs, PAHs, and nitrobenzene, as these parameters were not detected during baseline sampling.

8.6.4.2 Monitoring Results

The detection monitoring program for the cell well network provides for semi-annual sampling at each location. The 1999 monitoring results are presented in Tables 8-28 and 8-29. Results are reported for all parameters that exceeded the detection limit in at least one location.

Results of the first semi-annual sampling event, as shown in Table 8-28, represent the arithmetic mean of four replicate samples collected at each location. The mean for each parameter was compared to the corresponding baseline value presented in Table 8-27 to identify potential exceedences of baseline conditions. The following parameters exceeded baseline during the first half of 1999:

- MW-2032 chemical oxygen demand (COD)
- MW-2045 chromium, molybdenum
- MW-2046 nickel
- MW-2048 magnesium, sulfate

Results of the second semi-annual sampling event, as shown in Table 8-29, were compared to baseline values, and the following exceedences were reported:

- MW-2032 chromium, nickel, COD
- MW-2045 arsenic, chromium, molybdenum, nickel
- MW-2046 aluminum, barium, chromium, magnesium, nickel, COD
- MW-2047 COD
- MW-2048 sulfate

It is believed that the above-baseline data reported for the cell monitoring network during 1999 are a result of natural variations in the existing contamination plume underlying the site. Evaluation of the disposal cell leachate water quality and volume confirm that the elevated groundwater data are not the result of adverse impacts from the disposal cell. An investigation is currently underway to identify the contributing factors to the above-baseline occurrences. The investigation includes resampling of the wells, statistical evaluation and validation of the data, review of historical trends in groundwater levels and quality in the vicinity of the disposal cell, and statistical review of the established baseline values. Results will be presented in a demonstration report, to be prepared during 2000 in accordance with 40 CFR 269.98.

Table 8-27 Baseline Values for the Disposal Cell Compliance Wells

PARAMETER	MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Chloride (mg/l)	20.28	80.37	19.32	10.81	12.80	20.27
Fluoride (mg/l)	1.01	0.27	0.34	0.83	0.40	0.37
Nitrate (mg/l)	140.34	2.34	2.61	138.41	1.38	29.26
Sulfate (mg/l)	68.35	48.74	61.50	41.84	232	101
Aluminum (µg/l)	620	183	340	476	67.85	1013
Antimony (µg/l)	25.84	28.48	30.46	30.56	25.91	8.04
Arsenic (µg/l)	2.87	2.85	4.02	3.49	2.43	3.07
Barium (µg/l)	411	239	277	358	61.06	178
Beryllium (µg/l)	1.32	0.89	3.24	0.78	0.61	2.03
Cadmium (µg/l)	3.93	2.29	2.37	2.37	3.15	5.0
Calcium (µg/l)	219,750	116,150	179,860	168,360	122,620	121,350
Chromium (µg/l)	7.34	71.34	7.37	7.88	8.03	6.20
Cobalt (µg/l)	2.67	11.46	2.97	2.94	3.19	6.72
Copper (µg/l)	13.22	21.15	13.77	31.10	5.79	6.34
Iron (µg/l)	1,170	653	1,292	1,608	239	771
Lead (µg/l)	3.15	3.30	2.80	2.55	1.18	3.83
Lithium (µg/l)	24.67	29.02	16.65	92.67	15.87	25.53
Magnesium (µg/l)	60,890	52,130	59,510	94,920	43,840	31,070
Mercury (µg/l)	0.63	0.26	2.74	0.28	0.57	0.11
Manganese (µg/l)	56.30	186.52	173.48	189.00	16.15	25.66
Molybdenum (µg/l)	13.33	17.48	9.66	14.76	9.52	5.58
Nickel (µg/l)	6.96	608	9.81	24.35	5.68	10.05
Potassium (µg/l)	4,510	3,870	5,130	4,270	38,650	4,980
Selenium (µg/l)	8.55	3.65	3.75	6.44	14.51	3.60
Silver (µg/l)	24.81	4.10	4.58	4.44	4.05	1.67
Sodium (µg/l)	92,240	26,350	33,330	52,680	82,510	41,500
Thallium (µg/l)	6.71	5.88	5.58	5.12	5.99	6.54
Vanadium (µg/l)	10.59	17.22	20.38	18.87	12.66	12.87
Zinc (µg/l)	25.86	30.21	31.85	30.39	29.31	29.97
C.O.D. (mg/l)	2.83	17.93	5.72	5.66	7.81	16.94
Cyanide (µg/l)	13.09	4.77	3.11	4.07	4.54	2.76
T.D.S (µg/l)	1,262	568	637	1,051	913	552
T.O.X (µg/l)	0.085	0.045	0.644	0.041	0.145	0.028
T.O.C.(mg/l)	26.42	36.62	49.84	46.48	29.09	25.07
1,3,5-TNB (µg/l)	3.07	0.045	3.63	<DL	<DL	0.156
1,3-DNB (µg/l)	0.075	0.18	0.37	0.075	<DL	0.10
2,4,6-TNT (µg/l)	6.55	<DL	3.48	<DL	<DL	0.357
2,4-DNT (µg/l)	0.14	0.17	1.01	0.501	<DL	0.151
2,6-DNT (µg/l)	1.71	0.91	64.02	1.23	<DL	0.508
Radium-226 (pCi/l)	0.71	0.94	0.61	0.84	0.66	0.47
Radium-228 (pCi/l)	4.27	2.56	3.53	1.99	4.18	3.48
Thorium-228 (pCi/l)	0.261	1.90	0.206	0.241	0.181	1.00
Thorium-230 (pCi/l)	0.61	0.79	0.42	0.63	0.34	1.18
Thorium-232 (pCi/l)	0.44	0.26	0.14	0.17	0.15	0.74
Uranium, Total (pCi/l)	5.98	1.94	1.68	1.58	1.99	140
pH (Std. Units)	7.81	7.46	7.33	7.80	7.36	7.12
Specific Conductance (µmhos/cm)	2,021	1,114	1,061	1,545	1,122	543

Table 8-28 Summary of Detection Monitoring Data for Cell Well Network (June 1999)

PARAMETER	CONCENTRATION					
	GW-2032-B399	GW-2045-S199	GW-2046-S199	GW-2047-S199	GW-2048-S199	SP-6301-Q299
Chloride (mg/l)	6.66	64.63	17.23	5.97	7.13	12.50
Fluoride (mg/l)	0.21	<DL	<DL	<DL	0.27	0.27
Nitrate-N (mg/l)	10.93	1.36	1.73	62.58	0.92	11.40
Sulfate (mg/l)	24.88	22.20	48.33	23.63	250.50	52.48
Aluminum (µg/l)	<DL	<DL	<DL	<DL	<DL	753.75
Barium (µg/l)	194.25	198.25	170.25	318.25	39.98	140.75
Calcium (µg/l)	94,975	76,905	127,500	122,000	111,000	78,925
Chromium (µg/l)	3.90	193.78	<DL	3.13	2.50	2.83
Copper (µg/l)	<DL	5.50	<DL	<DL	4.03	1.36
Iron (µg/l)	139.50	349.38	192.25	382.75	67.18	775.25
Lead (µg/l)	<DL	<DL	<DL	<DL	<DL	1.33
Lithium (µg/l)	11.28	<DL	8.78	32.50	11.63	8.65
Magnesium (µg/l)	28,325	36,608	40,500	79,950	46,325	19,750
Manganese (µg/l)	6.68	26.73	19.33	36.90	1.06	53.33
Molybdenum (µg/l)	<DL	27.58	<DL	<DL	<DL	3.70
Nickel (µg/l)	<DL	535.3	10.73	11.58	<DL	<DL
Potassium (µg/l)	<DL	<DL	2,980	2,210	1,540	2,618
Selenium (µg/l)	<DL	<DL	<DL	<DL	14.35	<DL
Sodium (µg/l)	21,850	10,667	30,600	27,950	61,250	23,375
Thallium (µg/l)	<DL	<DL	<DL	<DL	3.55	<DL
Vanadium (µg/l)	<DL	<DL	<DL	<DL	<DL	1.81
Zinc (µg/l)	16.83	<DL	<DL	20.10	11.95	12.13
Total Dissolved Solids (mg/l)	422.3	507.5	537.8	880.5	705.5	430.8
Total Organic Carbon (mg/l)	<DL	<DL	1.510	<DL	1.508	1.710
TOX (mg/l)	0.006	0.007	0.015	<DL	0.010	<DL
1,3,5-Trinitrobenzene ((µg/l)	0.05	0.04	3.35	0.04	<DL	<DL
1,3-Dinitrobenzene (µg/l)	<DL	0.16	0.17	<DL	<DL	<DL
2,4,6-Trinitrotoluene (µg/l)	0.11	<DL	2.83	<DL	<DL	<DL
2,4-Dinitrotoluene (µg/l)	0.08	0.13	0.17	0.37	<DL	0.04
2,6-Dinitrotoluene (µg/l)	0.12	0.70	10.48	0.58	<DL	0.24
Thorium-230 (pCi/l)	<DL	0.160	<DL	<DL	<DL	0.129
Uranium, Total (pCi/l)	1.900	<DL	0.723	1.215	1.733	75.100
Methylene Chloride (µg/l)	<DL	13.0	<DL	<DL	<DL	<DL
Tetrachloroethene (PCE) (µg/l)	1.00	<DL	<DL	<DL	<DL	<DL
Trichloroethene (TCE) (µg/l)	1.00	<DL	<DL	<DL	<DL	<DL

Note: Parameters for which average concentration was below the highest detection limit for each sampling location are not included in table.
NS Parameter was not sampled.
<DL Average concentration was less than highest detection limit.

Table 8-29 Summary of Detection Monitoring Data for Cell Well Network (December 1999)

PARAMETER	CONCENTRATION					
	GW-2032-B699	GW-2045-S299	GW-2046-S299	GW-2047-S299	GW-2048-S299	SP-6301-Q499-L
Chloride (mg/l)	2.6	77	18.6	6.8	6.79	24.4
Fluoride (mg/l)	<DL	<DL	<DL	<DL	0.221	0.229
Nitrate-N (mg/l)	5.8	0.63	2	57.1	1.3	12.5
Sulfate (mg/l)	15	26.3	51.6	22.6	244	47.8
Aluminum (µg/l)	413	<DL	555	382	<DL	45.2
Arsenic (µg/l)	<DL	3.9	<DL	<DL	<DL	<DL
Barium (µg/l)	158	293	326	308	38.1	136
Beryllium (µg/l)	<DL	<DL	<DL	<DL	<DL	0.13
Calcium (µg/l)	49700	94000	172000	111000	103000	82600
Chromium (µg/l)	7.7	765	16.5	5.9	1.7	0.91
Cobalt (µg/l)	<DL	10.8	1	<DL	<DL	<DL
Copper (µg/l)	1.9	13.6	3.8	3.2	2.3	3
Iron (µg/l)	654	2710	1970	899	21.4	50.6
Lead (µg/l)	<DL	<DL	2.6	<DL	<DL	1.8
Lithium (µg/l)	4.3	3.2	7	11.5	5.1	16
Magnesium (µg/l)	30300	41000	61400	70900	46300	22500
Manganese (µg/l)	42.6	81.7	186	74	2.4	2.3
Molybdenum (µg/l)	2.5	86.7	1.5	2.3	1.6	4.1
Nickel (µg/l)	10.5	1070	72.1	7.2	<DL	1.5
Potassium (µg/l)	765	2820	3700	1690	2310	2480
Selenium (µg/l)	<DL	<DL	<DL	<DL	14.7	<DL
Sodium (µg/l)	7900	17800	29400	19800	56900	26800
Thallium (µg/l)	<DL	<DL	<DL	<DL	7	<DL
Vanadium (µg/l)	0.88	5.4	3.4	1.2	<DL	1.1
Zinc (µg/l)	5.8	<DL	14.9	6.6	6.4	9.3
Chemical Oxygen Demand (mg/l)	22.4	2.67	19.7	19.7	1.555	<DL
Total Dissolved Solids (mg/l)	110	493	520	650	701	430
Total Organic Carbon (mg/l)	0.87	1.69	2.6	1.2	4.5	4.15
TOX (mg/l)	0.0156	0.0056	0.118	0.027	0.0119	0.013
1,3,5-Trinitrobenzene ((µg/l)	<DL	<DL	2.9	<DL	<DL	<DL
2,4,6-Trinitrotoluene (µg/l)	<DL	<DL	2	<DL	<DL	<DL
2,4-Dinitrotoluene (µg/l)	<DL	0.13	0.14	0.22	<DL	0.052
2,6-Dinitrotoluene (µg/l)	0.046	0.39	1	0.23	0.011	0.2
Radium-226 (pCi/l)	0.481	0.506	<DL	0.406	0.525	0.93
Radium-228 (pCi/l)	<DL	<DL	<DL	0.95	<DL	<DL
Thorium-228 (pCi/l)	0.101	1.04	<DL	0.705	<DL	<DL
Thorium-230 (pCi/l)	0.69	0.607	0.273	0.618	<DL	<DL
Thorium-232 (pCi/l)	0.131	<DL	<DL	<DL	<DL	<DL
Uranium, Total (pCi/l)	2	<DL	<DL	1.1	1.54	64.6

Note: Parameters for which average concentration was below the highest detection limit for each sampling location are not included in table.
NS Parameter was not sampled.
<DL Average concentration was less than highest detection limit.

9. BIOLOGICAL MONITORING PROGRAM

9.1 Biological Program Highlights

The U.S. Department of Energy (DOE) conducted its third and final year of monitoring the establishment of wetlands created as mitigation for disturbance of wetland habitat at the Weldon Spring Site Remedial Action Project (WSSRAP) Borrow Area (see Section 9.4.2).

9.2 Program Description

Many of the biological sampling activities directed by DOE Orders 5400.1 and 5400.5 such as preoperational monitoring, effluent monitoring, and environmental surveillance are used to support the National Environmental Policy Act (NEPA) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) biological monitoring program and may include the collection and analysis of water, soil, foodstuffs, and biota samples.

Activities for the biological monitoring program are selected from the results of pathway analyses. Exposure pathways identified for human and ecological receptors are identified in Section 2.1 of the *Environmental Monitoring Plan* (Ref. 8). Complete pathways are those that show a link between one or more contaminant sources, through one or more environmental transport processes, to a human or ecological exposure point. These exposure pathways are used to direct biological sampling activities and determine the type of data that need to be gathered, documented, and reported.

Results of biological monitoring also provide data for the human ingestion pathways and dose calculations to native aquatic organisms. The remaining pathways are monitored to support biological risk assessment studies and compliance with environmental surveillance requirements.

9.3 Applicable Standards

DOE Order 5400.5 addresses the protection of native aquatic organisms from the potential bioaccumulation of radionuclides. The Order states that the dose absorbed by such organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.

The biological monitoring program provides supporting data on the possible ingestion of biota by humans for the dose estimates in Section 5. These calculations were based on the guideline from DOE Order 5400.5 stating that members of the public should not be exposed to radiation sources as a consequence of all routine DOE activities in any one year that could cause an annual effective dose equivalent greater than 100 mrem (1 mSv).

9.4 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring site by aquatic pathways. Contaminated surface water runoff from the site to off-site lakes and streams provides the main route of exposure to biota. Studies have been conducted to determine the uptake of contaminants on biota at on-site and off-site properties. Uranium is the main contaminant monitored in off-site surface water.

9.4.1 Fish Monitoring

The *Environmental Monitoring Plan* (Ref. 8) requires that sunfish samples from Busch Lake 35 be collected every other year or annually if average uranium concentrations in the lake waters are found to be statistically higher than the average concentration found in previous years. Samples collected in 1998 demonstrated that annual average uranium concentrations in the lake waters were no higher than in previous years, therefore no fish samples were collected during 1999.

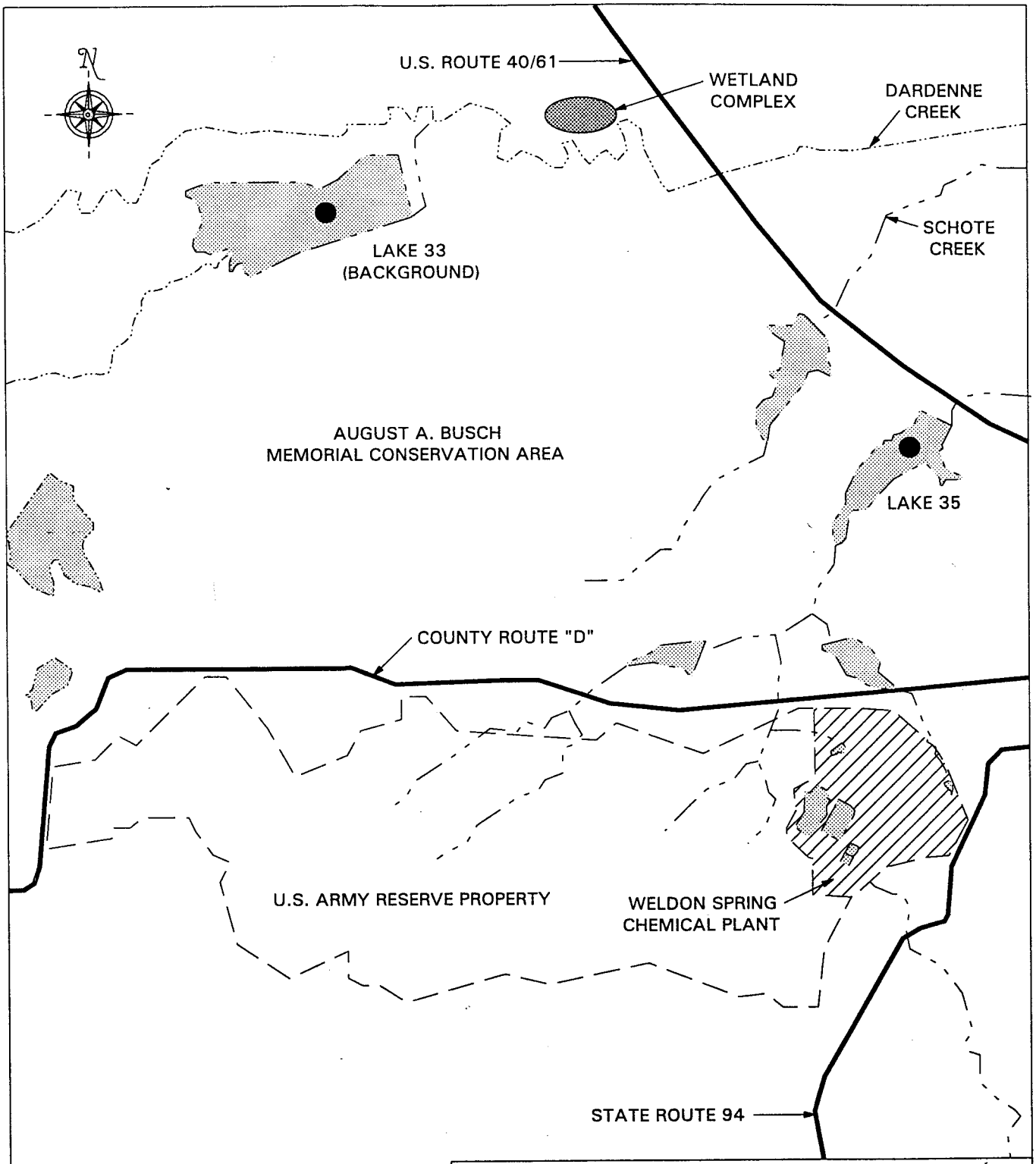
9.4.2 Wetland Monitoring

As mitigation for the disturbance of approximately 2.2 acres of wetland habitat at the Borrow Area, the DOE has partially funded the construction of a 57 acre wetland complex. These wetlands are located within the August A. Busch Memorial Conservation Area, northeast of Lake 33. Figure 9-1 shows the wetland complex location.

In accordance with the *Wetland Project Plan for COE Permit Application* (Ref. 42), the DOE is responsible for establishing five acres of replacement wetlands. Monitoring the establishment of these replacement wetlands began in 1997 and was completed in 1999. The monitoring included the collection of hydrological data (water depth, duration, extent, and saturation) and biological data (vegetation, avifauna, and herpetofauna) from the constructed wetlands. Results of the monitoring conducted the past 3 years indicate that the site is highly suitable for development of a sustainable wetland. Further discussion and results can be found in the *Wetlands Monitoring Report for the Weldon Spring Site Remedial Action Project* (Ref. 22).

9.5 Terrestrial Monitoring

The *Environmental Monitoring Plan* (Ref. 8) stipulated that monitoring of terrestrial foodstuffs would be conducted only if annual average air monitoring results indicate above background concentrations of radionuclides at critical receptor sites. Since annual air monitoring results did not show above background air monitoring results at these sites during 1998, foodstuff sampling did not take place in 1999.



LEGEND

● - BIENNIAL FISH SAMPLING LOCATIONS

NOT TO SCALE

ENVIRONMENTAL MONITORING LOCATIONS

FIGURE 9-1

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/VP/025/0396		
ORIGINATOR:	ML	DRAWN BY:	GLN	DATE:	5/11/00

10. ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

10.1 Quality Assurance Highlights

- Average relative percent differences calculated for groundwater, surface water, National Pollutant Discharge Elimination System (NPDES) samples and springs were within the 20% criterion recommended by the Contract Laboratory Program (CLP).

- The data validation program accepted 99.6% of the data selected for validation qualifying in 1999.

10.2 Program Overview

The environmental quality assurance program includes management of the quality assurance and quality control programs, plans, and procedures governing environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the WSSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the WSSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent quality problems from the time a sample is collected until the associated data are evaluated and utilized. Key elements in achieving the goals of this program are compliance with the quality assurance program and environmental quality assurance program procedures; personnel training; compliance assessments; use of quality control samples; complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness.

10.2.1 Quality Assurance Program

The *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 43) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 414.1A.

10.2.2 Environmental Quality Assurance Project Plan

The quality assurance requirements for WSSRAP environmental data operations are addressed in the *WSSRAP Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 44). The EQAPjP outlines the appropriate requirements of U.S. Environmental Protection Agency (EPA) QA/R-5 (Ref. 45) for characterization and routine monitoring at the WSSRAP. The EQAPjP does not supersede the QAP, but rather expands on the specific requirements of environmental monitoring and characterization activities.

The primary purpose of this document is to specify the quality assurance requirements for environmental data operations of the WSSRAP. The EQAPjP is also supported by standard operating procedures (SOPs), the *Sample Management Guide* (SMG) (Ref. 46), the *Environmental Safety and Health Department Plan* (Ref. 47), the *Environmental Monitoring Plan* (EMP) (Ref. 8), and sampling plans written for specific environmental sampling tasks.

10.2.3 Sample Management Guide

The *Sample Management Guide* (SMG) summarizes the data quality requirements for collecting and analyzing environmental data. The SMG describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. Guidance on developing data quality objectives for specific investigations is also detailed. The SMG details the specific requirements of the EQAPjP.

10.2.4 Environmental Monitoring and Quality Assurance Standard Operating Procedures

SOPs have been developed for routine activities at the WSSRAP. Environmental monitoring SOPs are generally administered by the Environmental Safety and Health (ES&H) Department, and Quality Assurance SOPs are administered by the Project Quality Department. These two departments are responsible for most SOPs used to administer the environmental quality assurance program described in this section. Controlled copies of SOPs are maintained in accordance with the document control requirements of the QAP (Ref. 43).

10.2.5 Evaluation and Presentation of Data

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in reporting and calculations of annual averages where available. Uncensored data are those data that do not represent a ND (nondetect) and instead report instrument responses that quantitate to values below the reported detection limit. These types of data are designated by parentheses around the data value, for example "(1.17)". When there was no instrument response, nondetect data were used in calculations of averages at a value of one-half the detection limit (DL/2), as specified in Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*.

10.2.6 Independent Assessments and Appraisals

The environmental programs are assessed by the Project Quality Department. They evaluate compliance by performing surveillances and independent assessments of the environmental programs and generate assessment reports to track deficiencies and corrective actions.

10.2.7 Subcontracted Off-Site Laboratories Programs

Subcontracted off-site laboratories that performed analyses used for the preparation of this report use Contract Laboratory Program (CLP) methodologies when applicable. For certain analyses (such as radiochemical and wet chemistry) the laboratories use EPA 600 (drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis of each sample. Each of the subcontracted off-site laboratories has submitted to the WSSRAP a site-specific Quality Assurance Project Plan (QAPjP) and controlled copies of their SOPs. The QAPjPs and SOPs are reviewed and approved by the PMC before any samples are shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. All of the laboratories currently being used by the WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability to perform work according to the specifications of their contracts. Quality assurance assessments are performed routinely to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

10.3 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the appropriate analytical and field measurement methodologies; (2) collection and evaluation of quality control samples; (3) accuracy, precision, and completeness evaluations; and (4) preservation and security of all applicable documents and records pertinent to the environmental monitoring programs.

10.3.1 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the WSSRAP comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring follow the EPA CLP requirements (metal and organic methodologies) (Ref. 48 and Ref. 50), and the EPA drinking water and radiochemical methodologies or methods that are reviewed and approved by the PMC prior to analysis of each sample. Field measurement methodologies typically follow the *American Public Health Association Standard Methods for the Examination of Water and Wastewater* (Ref. 49).

10.3.2 Quality Control Samples

Quality control samples for environmental monitoring are collected in accordance with the required sampling plan, which specifies the frequency of quality control sample collection. Quality control samples are normally taken in accordance with guidelines in the EPA CLP (Ref. 50).

Descriptions of the QC samples collected at the WSSRAP are detailed in Table 10-1.

10.3.3 Accuracy, Precision, and Completeness

At a minimum, the WSSRAP Data Validation Group determines the analytical accuracy, precision, and completeness of 10% of the environmental data collected. Data validation is required under DOE Order 5400.1.

10.3.4 Preservation and Security of Documents and Records

Requirements for preservation and security of documents and records are specified in DOE Order 414.1A. All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

10.4 Quality Assurance Sample Results

The quality assurance program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

10.4.1 Duplicate Results Evaluation

Two kinds of duplicate analyses were evaluated in 1999, matrix duplicates and secondary duplicates. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. A secondary duplicate is an additional aliquot of the original sample that is split by the WSSRAP, placed in a separate container, and sent to a secondary laboratory. Matrix duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interferences of sample matrixes.

Table 10-1 QC Sample Description

TYPE OF QC SAMPLE	DESCRIPTION
Water Blank (WB)	Monitors the purity of distilled water used for field blanks and decontamination of sampling equipment. Water blanks are collected directly from the distilled water reservoir in the WSSRAP laboratory.
Field Blank (FB)	Monitors potential contaminants, such as dust or volatile compounds, that may be introduced at the site of sample collection. Field blanks are collected in the field at The same time of sample collection activities.
Equipment Blank (EB)	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank (TB)	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks shall be collected in the WSSRAP laboratory with prepurged distilled water.
Field Replicate (FR)	Monitors field conditions that may affect the reproducibility of samples collected from a given location. Field replicates are collected in the field at the same location.
Blind Duplicate	A duplicate that provides an unbiased measure of laboratory precision. Blind duplicates are additional aliquots of the routine sample taken in the field and given an altered identification code to conceal the samples identity from the laboratory.
Matrix Spike* (MS)	Assesses matrix and accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate* (DU)	Assesses matrix and precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate* (MD)	Assess matrix and precision of laboratory measurements for organic compounds. The matrix spike duplicates is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.
Secondary Duplicate (SD)	A duplicate that compares the primary laboratory with a secondary laboratory, providing an additional check on the performance of the primary laboratory. The secondary duplicate is an additional aliquot of the routine sample that is sent to a secondary laboratory.

* A laboratory sample is split from the parent sample.

Generally, matrix duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Secondary duplicate samples were collected on a monthly basis. Typically, duplicate samples were analyzed for more common parameters (e.g., uranium, inorganic anions, and metals).

When matrix and secondary duplicate samples were available, the average relative percent difference was calculated. This difference represents an estimate of precision. The equation used, (RPD) as specified in the *USEPA Contract Laboratory Program, Inorganic Scope of Work*, (Ref. 50), was:

$$RPD = |S-D| / ((S+D)/2) \times 100\%$$

where S = concentration in the normal sample
D = concentration in the duplicate analysis

The RPD was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 10-2 summarizes the data of calculated RPD for groundwater (including springs) and surface water (including National Pollutant Discharge Elimination System [NPDES]) samples. Both the matrix duplicates and the secondary duplicates are summarized together. Parameters that were not commonly analyzed for and/or were not contaminants of concern were not evaluated.

Table 10-2 Summary of Calculated Relative Percent Differences

PARAMETER	N	AVG. RPD	MIN. RPD	MAX. RPD
Arsenic	64	3.77	0.00	8.80
Chemical Oxygen Demand	43	2.30	0.00	6.13
Chloride	50	2.85	0.00	20.60
Chromium	69	9.98	0.00	68.26
Fluoride	50	3.86	0.00	17.12
Lead	69	6.57	0.00	8.70
Manganese	41	9.02	0.00	60.50
Mercury	60	15.50	0.00	47.19
Nitrate-N	74	4.45	0.00	56.78
Selenium	68	11.11	0.00	150.19
Sulfate	63	1.69	0.00	12.20
Total Suspended Solids	57	4.54	0.00	17.00
Uranium, Total	82	6.69	0.00	42.98

N = Data Population

The results in Table 10-2 demonstrate that all average relative percent differences calculated were within the 20% criterion as recommended in the CLP (Refs. 48 and 50). As a result, duplicate sample analyses in 1999 were of acceptable quality.

10.4.2 Blank Sample Results Evaluation

Various types of blanks are collected by the WSSRAP to assess the conditions and/or contaminants that may be introduced during sample collection and transportation. These conditions and contaminants are monitored by collecting blank samples to ensure that environmental samples are not being contaminated. Blank samples evaluate the:

- Environmental conditions under which the samples (i.e., volatile analyses) were shipped (trip blanks).

- Ambient conditions in the field that may affect a sample during collection (field/trip blanks).

- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).

- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).

- Presence or absence of contamination potentially introduced through sample preservation and/or sample containers.

Sections 10.4.2.1 through 10.4.2.4 discuss the sample blank analyses and the potential impact of blank contamination upon the associated samples.

To evaluate whether samples were potentially impacted by blank contamination, all samples in the same analytical batch as the blank were reviewed. If the samples and blank had roughly the same concentration, the samples were considered to be potentially contaminated. For all parameters except radiochemical parameters, the sample concentration had to be above the detection limit and less than five times the blank concentration to be potentially contaminated. For radiochemical parameters to be potentially impacted by blank contamination, the concentration had to be above the detection limit, and the normalized absolute difference (NAD) had to be less than 2.58. The NAD was calculated as follows:

$$NAD = \frac{|S - B|}{\sqrt{Err_S^2 + Err_B^2}}$$

where:

S = concentration of the sample
B = concentration of the blank
Err_s = error associated with the sample
Err_B = error associated with the blank

10.4.2.1 Trip Blank Evaluation

Trip blanks are collected to assess the impact of sample collection and shipment on groundwater and surface water samples analyzed for volatile organic compounds. Trip blanks are sent to the laboratory with each shipment of volatile organic samples.

In 1999, 62 trip blanks were analyzed for volatile organic compounds. Detections for acetone were found in one blank, methylene chloride in five blanks, and 2-butanone in one blank. All environmental samples associated with the seven blank detections listed above were evaluated. Seventeen samples were potentially impacted: 11 samples where methylene chloride had been detected, and six samples where 2-butanone had been detected. None of the other samples evaluated exceeded the recommended CLP criterion.

10.4.2.2 Field Blank Evaluation

Field blank samples are collected at monitoring locations just prior to, or immediately after, actual samples are collected. The field blanks are collected to assess the ambient conditions at the sample locations and are generally for the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

In 1999, two field blanks were collected. Table 10-3 presents the ratio of detects to total number of blanks collected for each parameter having results above the detection limits. The table also presents the ratio of potentially impacted samples to the total number of samples analyzed with the blank. In cases where there were no detects in any blank, the ratio of potentially impacted samples to the total number of samples is not applicable.

Table 10-3 Summary of Field Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Arsenic	0 of 2 (0%)	N/A
Barium	2 of 2 (100%)	0 of 7 (0%)
Cadmium	0 of 1 (0%)	N/A
Chloride	0 of 0 (0%)	N/A
Chromium	0 of 1 (0%)	N/A
Fluoride	0 of 0 (0%)	N/A
Gross Alpha	0 of 1 (0%)	N/A
Gross Beta	0 of 1 (0%)	N/A
Lead	0 of 1 (0%)	N/A
Mercury	0 of 1 (0%)	N/A
Nitrate as N	0 of 1 (0%)	N/A
Nitroaromatics	0 of 2 (0%)	N/A
Radium-226	0 of 1 (0%)	N/A

Table 10-3 Summary of Field Blank Parameter Results (Continued)

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Radium-228	0 of 1 (0%)	N/A
Selenium	0 of 1 (0%)	N/A
Silver	0 of 1 (0%)	N/A
Sulfate	0 of 1 (0%)	N/A
Thorium-228	0 of 1 (0%)	N/A
Thorium-230	0 of 1 (0%)	N/A
Thorium-232	0 of 1 (0%)	N/A
Uranium, total	0 of 2 (0%)	N/A
Volatiles	0 of 1 (0%)	N/A
Semi-volatiles	0 of 0 (0%)	N/A

N/A Not applicable

10.4.2.3 Equipment and Bailer Blank Evaluation

Equipment and bailer blanks are collected by rinsing decontaminated equipment and bailers with distilled water, and collecting the rinse water. This procedure is used to determine the effectiveness of the decontamination process. At the WSSRAP, most of the groundwater samples are collected from dedicated equipment, and surface water is collected by placing the sample directly into a sample container. No equipment blanks were collected in 1999 for non-soil sampling.

10.4.2.4 Distilled Water Blank Evaluation

Water blank samples are collected to evaluate the quality of the distilled water used to decontaminate sampling equipment and to assess whether contaminants are present in the water used for field and trip blanks. Water blank samples also serve as laboratory blanks. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks.

In 1999, 10 water blanks were collected. Table 10-4 presents the ratio of detects to the total number of blanks collected for each parameter that had results above the detection limit. The table also presents the ratio of potentially impacted samples to the total number of samples analyzed with the blank. In cases where there were no detects in any blank, the ratio of potentially impacted samples to the total number of samples is not applicable. In cases where there were no samples analyzed with the blank, a zero has been placed in that column and no percentage has been shown.

Table 10-4 Summary of Distilled Water Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Alkalinity	5 of 10 (50%)	0
Arsenic	0 of 10 (0%)	N/A
Barium	5 of 10 (50%)	0 of 32 (0%)
Cadmium	0 of 10 (0%)	N/A
Chloride	2 of 10 (20%)	0 of 3 (0%)
Chromium	3 of 10 (30%)	18 of 21 (86%)
Cyanide, Total	1 of 10 (10%)	0
Fluoride	0 of 10 (0%)	N/A
Lead	2 of 10 (20%)	6 of 7 (86%)
Mercury	0 of 10 (0%)	N/A
Nitrate as N	5 of 10 (50%)	5 of 19 (26%)
Nitroaromatics	0 of 10 (0%)	N/A
PAHs	0 of 10 (0%)	N/A
PCBs	0 of 10 (0%)	N/A
Radium-226	5 of 10 (50%)	3 of 5 (60%)
Radium-228	1 of 10 (10%)	0
Selenium	0 of 10 (0%)	N/A
Silver	3 of 10 (30%)	7 of 18 (39%)
Sulfate	1 of 10 (10%)	0 of 3 (0%)
Thorium-228	2 of 10 (20%)	5 of 7 (71%)
Thorium-230	6 of 10 (60%)	9 of 11 (82%)
Thorium-232	1 of 10 (10%)	2 of 4 (50%)
Uranium-234	1 of 5 (20%)	0
Uranium-235	0 of 6 (0%)	N/A
Uranium-238	1 of 6 (17%)	0
Uranium, Total	0 of 10 (0%)	N/A
Volatiles	1 of 6 (17%)	0 of 3 (0%)

N/A Not Applicable

10.5 1999 Data Validation Program Summary

Data validation programs at the WSSRAP involve reviewing and qualifying at least 10% of the data collected during a calendar year. The data points represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 10-5 identifies the number of quarterly and total data points that were selected for data validation, and indicates the percentage of those selected that were complete. Data points presented in this table include all sample types.

Table 10-5 WSSRAP Validation Summary for Calendar Year 1999

CALENDAR QUARTER	NO. OF DATA POINTS COLLECTED	NO. OF DATA POINTS SELECTED FOR VALIDATION	PERCENT SELECTED	NO. OF VALIDATED DATA POINTS REJECTED	COMPLETENESS[a]
Quarter 1	16,347	2,027	12.4%	4	99.8%
Quarter 2	40,995	4,103	10.0%	13	99.7%
Quarter 3	26,280	2,846	10.8%	30	98.9%
Quarter 4	15,551	1,737	11.2%	0	100.0%
1999 Total	99,173	10,682	10.8%	47	99.6%

(a) Completeness is a measure of acceptable data. The value is given by:

$$\text{Completeness} = \frac{(\#\text{ validated} - \#\text{rejected})}{\#\text{ validated}}$$

Reflects all validatable data for the calendar year.

Table 10-6 identifies validation qualifiers assigned to the selected data points as a result of data validation. The WSSRAP validation technical review was performed in accordance with the U.S. EPA *Contract Laboratory Program Statement of Work for Inorganics Analysis* (Ref. 50), the U.S. EPA *Contract Laboratory Program Statement of Work for Organic Analysis* (Ref. 48), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 51). For calendar year 1999, 100.0% of data validation has been completed. Data points presented in this table include groundwater, surface water, spring and seep water, NPDES, and NESHAPs samples only.

Table 10-7 identifies the average accuracy and precision for anion, metals, nitroaromatic, radiochemical, and miscellaneous parameters. The accuracy values are based on the percent recoveries of the laboratory control samples, and the precision values are based on the relative percent difference between laboratory control sample duplicates. The data population size associated with each accuracy and precision value is listed as "N." Data points presented in this table include groundwater, surface water, spring and seep, and NPDES samples only.

Table 10-6 WSSRAP Validation Qualifier Summary for Calendar Year 1999

	NO. OF DATA POINTS								
	ANIONS	METALS	MISC.	NITRO-AROMATICS	PESTICIDES /PCBs	RADIO-CHEMICAL	SEMI-VOLATILES	VOLATILES	TOTAL
Accepted	53	275	39	3	197	1,082	709	741	3,099
Rejected	0	0	0	0	1	0	31	3	35
Not Validatable	0	0	0	0	0	6	0	0	6
Total	53	275	39	3	198	1,088	740	744	3,140
	PERCENTAGES								
Accepted	100.0%	100.0%	100.0%	100.0%	99.5%	99.4%	95.8%	99.6%	98.7%
Rejected	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	4.2%	0.4%	1.1%
Not Validatable	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1999

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
IONS							
Chloride	1	95	0	95	1	0	1
Fluoride	1	98	0	98	8	0	8
Nitrate	2	97.4	95	99.8	1.3	1	1.6
Sulfate	1	96	0	96	4	0	4
METALS							
Arsenic	1	103.3	0	103.3	1	0	1
Barium	1	102	0	102	1	0	1
Cadmium	1	99	0	99	1	0	1
Chromium	1	98	0	98	1	0	1
Lead	1	95	0	95	0	0	0
Mercury	1	92	0	92	1	0	1
Selenium	1	100	0	100	0	0	0
Silver	1	99	0	99	1	0	1
MISC.							
Oil & Grease	1	96.9	0	96.9	---	---	---
RADIOCHEMICAL							
Uranium, Total	1	98	0	98	5	0	5
VOLATILES							
1,1-Dichloroethene	1	105	0	105	---	---	---
Benzene	1	97	0	97	---	---	---
Chlorobenzene	1	95	0	95	---	---	---
Toluene	1	94	0	94	---	---	---
Trichloroethene	2	93	87	99	---	---	---

N = Data population.

11. SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 8).

11.1 Off-Site Migration of Uranium in Storm Water

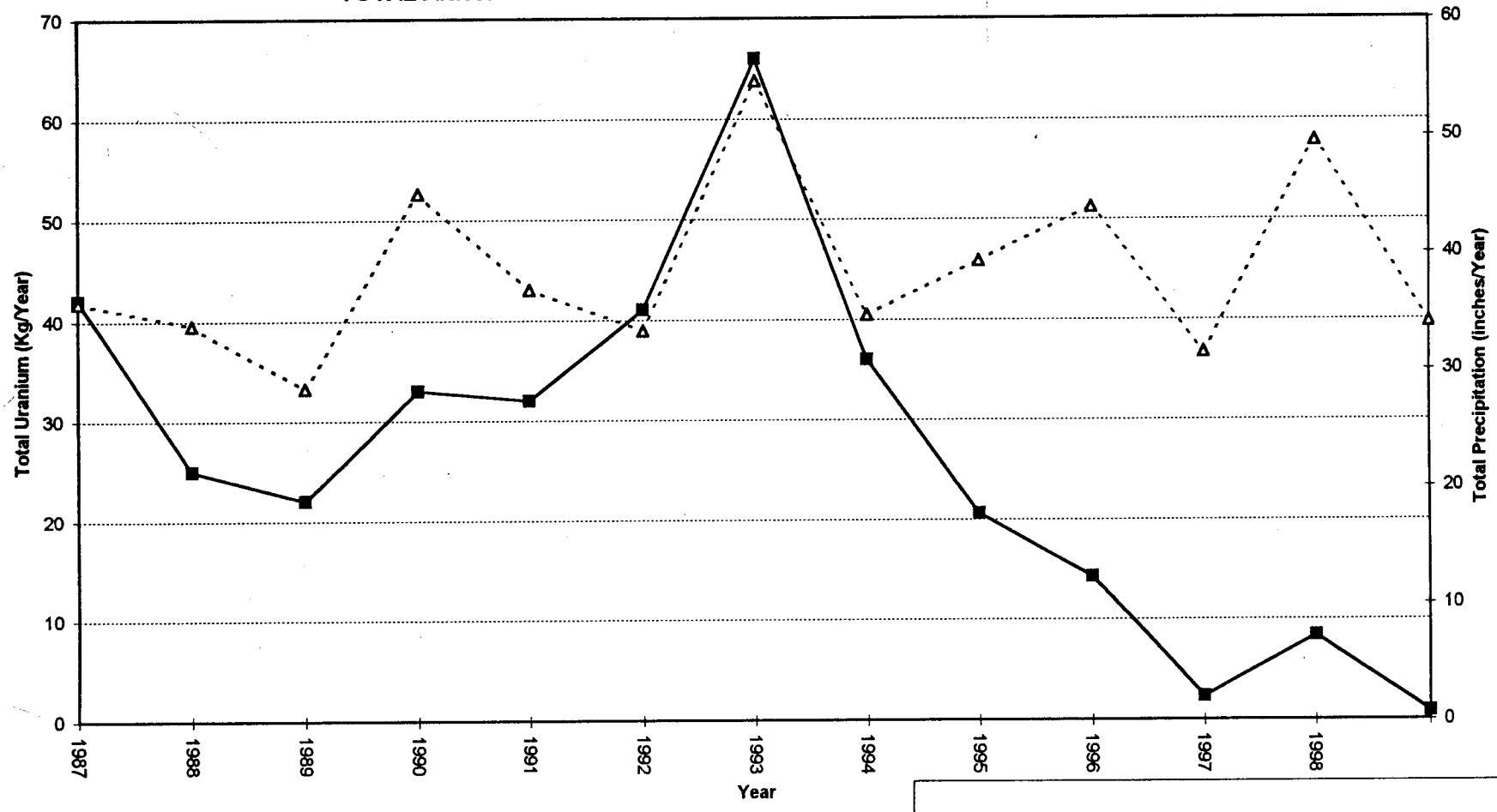
In an effort to determine the effect of site activities on the off-site migration of uranium in storm water at the three major National Pollutant Discharge Elimination System (NPDES) outfalls (NP-0002, NP-0003, NP-0005), the data for the years 1987 through 1994 were reviewed and corrected for several factors, as required, to normalize the data. The corrections were for precipitation, watershed areas, and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 52).

These data have been updated with the inclusion of 1995, 1996, 1997, 1998, and 1999 data. This recent data did not require correction. The annual mass, annual precipitation, and mass per inch of precipitation are tabulated in Table 11-1. The annual precipitation and total annual mass discharged off site through 1999 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass per inch of precipitation and annual precipitation are plotted for 1987 through 1999 for all three outfalls in Figure 11-4.

Table 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls[a]

		OUTFALL						
		NP-0002		NP-0003		NP-0005		
YEAR	PPT (Inches)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	TOTAL MASS/YEAR (kg) (a)
1987	35.8	42	1.17	362	10.11	38	1.06	442
1988	33.9	25	0.74	176	5.19	26	0.77	227
1989	28.5	22	0.77	35	1.23	15	0.53	72
1990	45.1	33	0.73	17.7	0.39	25	0.55	75.7
1991	36.9	32	0.87	73	1.98	27	0.73	132
1992	33.4	41	1.23	75	2.25	16	0.48	132
1993	54.7	66	1.21	163	2.98	31	0.57	260
1994	34.7	36	1.03	49	1.41	12	0.34	97
1995	39.3	20.6	0.52	12.6	0.32	5	0.13	38.2
1996	43.9	14.3	0.33	19.1	0.44	4	0.09	37.4
1997	31.5	2.3	0.07	19.2	0.61	0.5	0.02	22.0
1998	49.6	8.4	0.17	13.3	0.27	0.57	0.01	22.3
1999	34.1	0.83	0.02	3.9	0.11	0.67	0.02	5.4

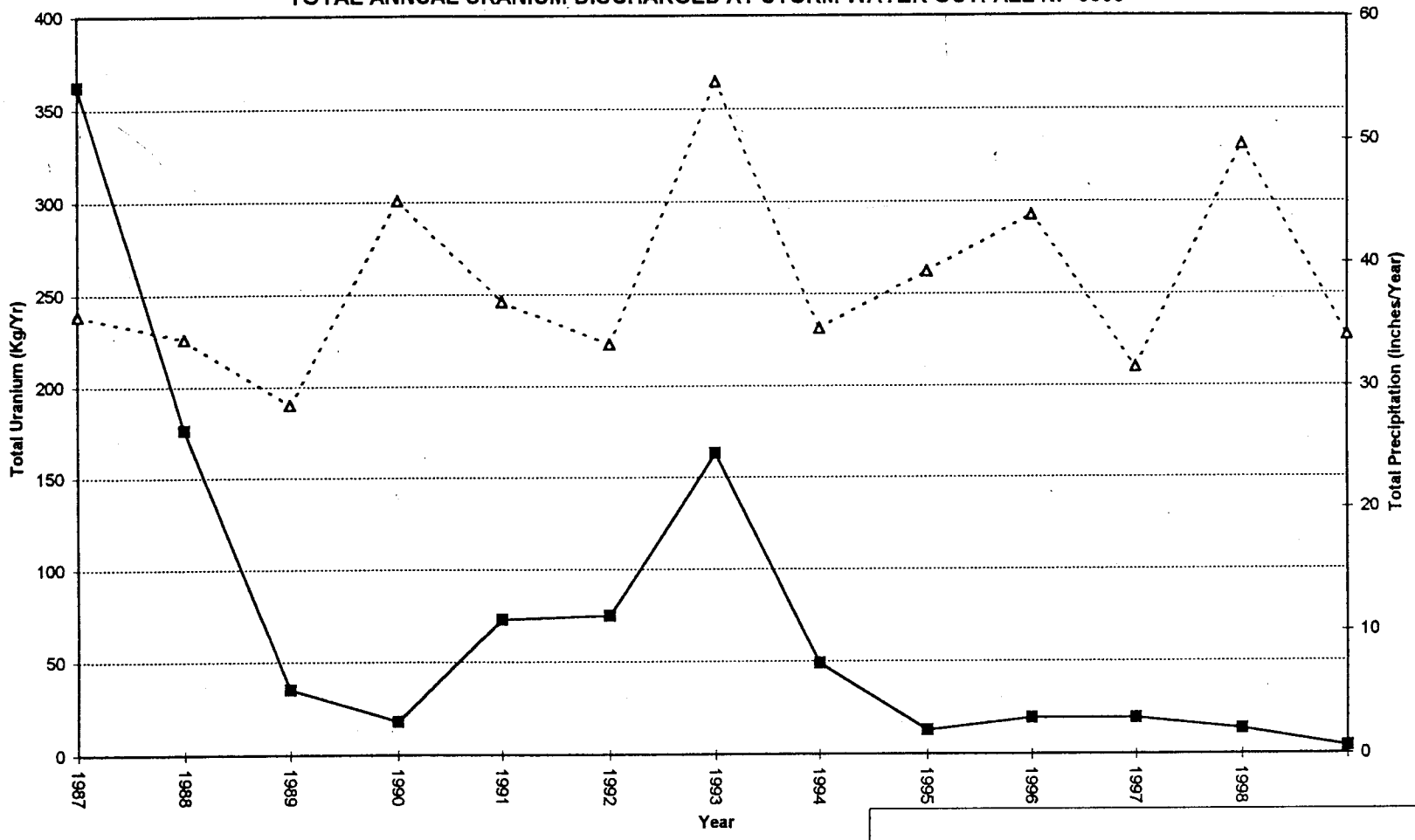
PPT Precipitation
(a) Includes Outfalls NP-0002, NP-0003 and NP-0005. Other outfalls contribute negligible amounts.



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0002

FIGURE 11-1

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/PI/020/0598		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	4/25/00

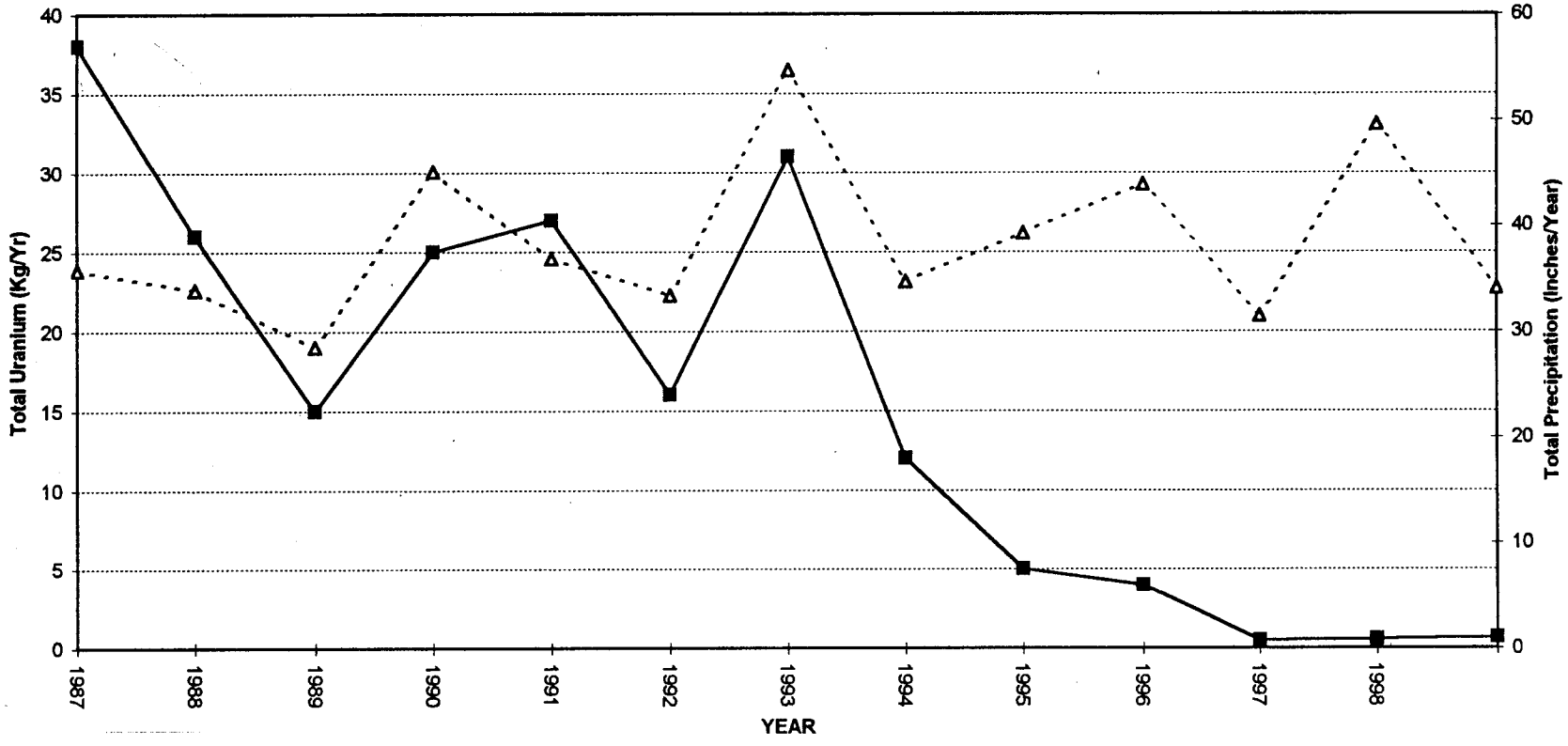


TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0003

FIGURE 11-2

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/PI/021/0598		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	4/25/00

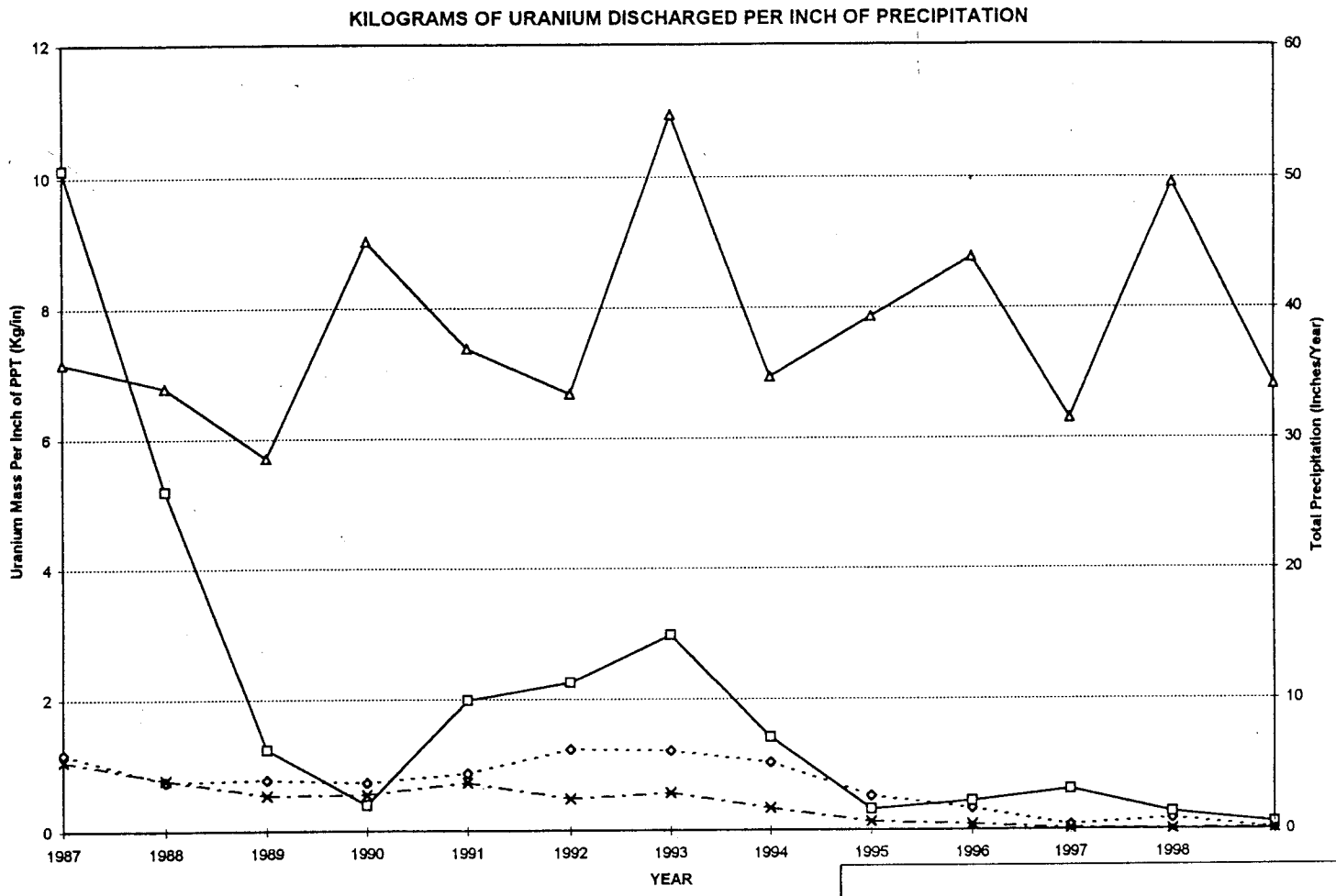
TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0005



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0005

FIGURE 11-3

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/PI/022/0598		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	4/25/00



KILOGRAMS OF URANIUM DISCHARGED PER INCH OF PRECIPITATION

FIGURE 11-4

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/PI/023/0598		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	4/25/00

11.1.1 Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of the Frog Pond area and receives runoff from the eastern section of the chemical plant area. Figure 11-1 indicates that uranium migrating off site initially decreased or increased in relative proportion to annual precipitation before remediation started. Building dismantlement occurred in 1992, which appears to have increased the mass of uranium migrating off site, although precipitation was less than the previous year. With the completion of building dismantlement, the positive correlation of uranium versus precipitation resumed until 1995 when precipitation increased and uranium decreased. This trend continued into 1996.

Mass reduction in 1995 was presumed to be due to precipitation patterns, since the reductions were similar at all three outfalls, although activities in the three watersheds differed. The reduction in 1996 is believed to be due to action of the sedimentation basin in addition to the removal of contaminated soil and building foundations. The downward trend continued in 1997. During 1997, storm water was diverted around Frog Pond, and Frog Pond was removed in mid 1998. Total mass at Outfall NP-0002 increased slightly for 1998. Increase in precipitation during 1998 is suspected as the cause.

The mass for 1999 was much reduced, as was the mass per inch of precipitation. This reduction is attributed to the NP-0002 watershed being almost completely remediated, and a significant reduction from 1998 storm water runoff levels. Precipitation in 1999 was less than in 1998, and there were few major storm events, which reduced runoff from the site.

11.1.2 Storm Water Outfall NP-0003

Figure 11-2 indicates that uranium migrating off site sharply decreased from 1987 to 1989 at Outfall NP-0003. The reduction for 1988 is assumed to be due to precipitation patterns since there was no other activity in the watershed. The reduction in 1989 was due to construction of the Ash Pond diversion channel, which began in November of 1988 and was completed in April of 1989, along with lower precipitation in 1989. Prior to construction of the diversion channel, most of the water in the watershed flowed through Ash Pond, which is a highly contaminated area. Following construction of the diversion channel, the only water that flowed from Ash Pond was precipitation that fell directly on the pond area.

Construction of the diversion channel made the fluctuations in annual uranium mass at Outfall NP-0003 highly dependent on the flow from Ash Pond. During the summer, and other dry periods, there could be little or no flow from the pond. As a result, the diversion channel flow (from a much less contaminated area of the site) made up the bulk of the flow. This caused overall lower uranium levels at the outfall during periods of normal precipitation. During winter, when the Ash Pond soils may have become saturated and precipitation amounts generally have been higher, flow from Ash Pond increased and concentrations at the outfall trended higher.

The mass in 1990 was again reduced over the previous year, although precipitation was much higher. This may have been a result of precipitation patterns and/or the times the samples were taken (i.e., no flow from Ash Pond). During 1991 and 1992, precipitation was less than in 1990, but uranium mass was higher. Again, this presumably was due to precipitation patterns and the time of sample collection.

Uranium mass increased greatly in 1993 because precipitation increased dramatically and Ash Pond discharged throughout the year. Mass decreased in 1994 with the decrease in precipitation, and a soil cover was placed over the South Dump area of Ash Pond during the middle of the year. Mass was again reduced in 1995 with an increase in precipitation. This was likely the result of precipitation patterns (because reductions were similar at all three outfalls) and the construction during 1995 of a sedimentation basin immediately upstream of Outfall NP-0003. Mass increased slightly in 1996 due to increased precipitation and the storage of contaminated soil and debris in Ash Pond. With the storage of soil and debris in Ash Pond, the water was managed and was not discharged to the sedimentation basin unless it was less than the 600 pCi/l (22.2 Bq/l) Derived Concentration Guideline (DCG). With the storage of contaminated materials in Ash Pond, the mass of uranium at Outfall NP-0003 was expected to be highly dependent on precipitation and water discharged from Ash Pond. The mass of uranium discharged during 1997 was slightly higher than that discharged during 1996, even though precipitation was much less. This was likely the result of the storage of contaminated materials in Ash Pond. During 1998, total mass at Outfall NP-0003 was less than during 1997, even though precipitation was much higher. The decrease is assumed to be the result of management of Ash Pond water and the removal of contaminated materials from Ash Pond during 1998.

The mass of uranium migrating off site at Outfall NP-0003 was less than the 1998 mass. This reduction is attributed to a reduction in precipitation and remediation efforts in the Ash Pond area. The entire Ash Pond area and the chipped wood storage area were remediated and confirmed clean during 1999. Uranium levels are expected to stabilize at these low levels.

11.1.3 Storm Water Outfall NP-0005

Figure 11-3 indicates that the mass of uranium migrating off site at Outfall NP-0005 has been generally proportional with annual precipitation. Construction of the site water treatment plant, which began in 1992, appears to have had little effect on the outfall, even though it involved substantial earth disturbance for construction of the effluent and equalization basins. A siltation basin was constructed to settle sediments from the water flowing off the treatment plant area. The storm water from the site water treatment plant siltation basin has historically contained less than 10 pCi/l (0.37 Bq/l) uranium. The other major source for the Outfall (until it was remediated in 1996) was a watershed that drained the highly contaminated Building 301 area. This area was partially capped during 1994 to decrease the concentration of uranium in storm water leaving the area.

The concentration of uranium in storm water from individual sampling events was highly dependent on precipitation rates, periods between precipitation, and the ratio of flow from the sedimentation basin and the Building 301 area. The mass of uranium migrating off site was reduced in 1995 and again in 1996. The reduction in 1995 is likely the result of precipitation patterns, because all three outfalls had similar reductions. The watershed for NP-0005 was remediated during 1996. This resulted in another reduction in uranium mass leaving the site in 1996. The mass of uranium migrating off site at Outfall NP-0005 for 1997 was much reduced over 1996 because 1997 was the first complete year where the watershed was almost completely remediated. Uranium mass is expected to remain close to background levels at Outfall NP-0005. The total mass at Outfall NP-0005 remained low for 1998, despite the increased precipitation, because the area has been remediated and there was very little soil disturbance in the watershed during 1998.

There was a slight increase in mass at Outfall NP-0005 in 1999, although the total mass remained low. The slight increase in mass is attributed to a collection sump near the chemical stabilization and solidification (CSS) area that prevents water from flowing to the NP-0003 watershed. The water is collected to allow construction of the cell berm. The water is then pumped to Outfall NP-0005. The water that collects in the sump is from an area that is only partially remediated and slightly higher in uranium than other NP-0005 waters, thus causing the slight increase.

11.1.4 Mass of Uranium Per Inch of Precipitation

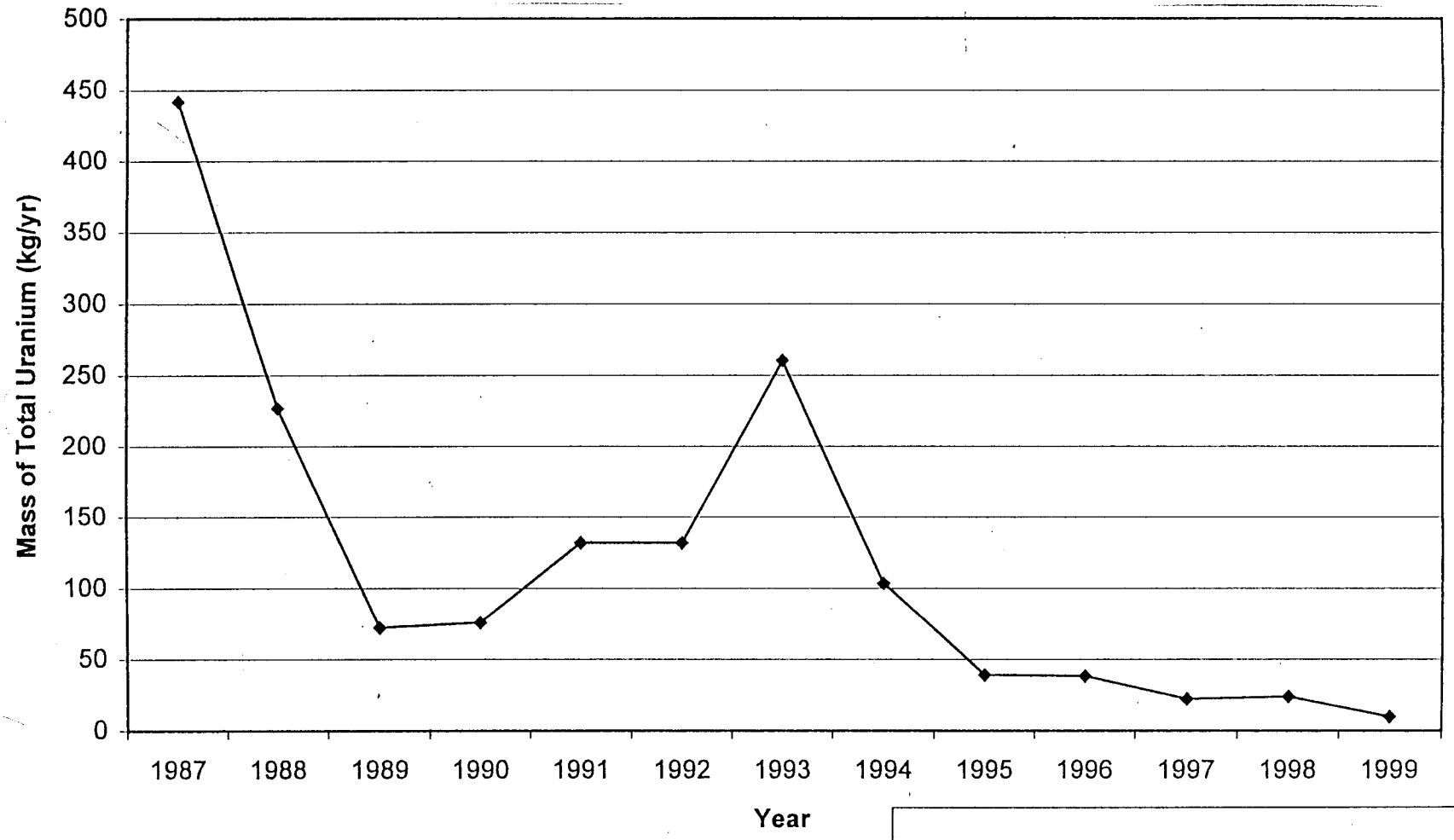
Figure 11-4 and Table 11-1 indicate that mass of uranium migrating from the site per inch of precipitation has relatively flat trend lines for the three major outfalls since 1995. This indicates that, all other factors remaining constant, the mass of uranium migrating off site is dependent upon annual precipitation and the contamination level in the watershed. Outfalls NP-0002 and NP-0005 show similar levels, with NP-0003 showing relatively higher levels. This is to be expected because the Outfall NP-0003 watershed contains Ash Pond, which was a highly contaminated area. Variations may be due to precipitation patterns, soil disturbance, or remediation and in the case of Outfall NP-0003, the storage of contaminated materials in Ash Pond. Outfalls NP-0002 and NP-0005 have trended downward as a result of remediation efforts in the watershed. Outfall NP-0003 increased slightly for 1997 because of the storage of contaminated materials in Ash Pond, but decreased during 1998 despite the increase in precipitation. With remediation of the Ash Pond area in 1999, the mass per inch of precipitation was reduced at Outfall NP-0003. The mass per inch of precipitation is expected to trend downward with remediation of major outfalls in the watersheds.

11.1.5 Annual Migration of Uranium Mass from the WSSRAP

The mass of uranium that migrated off site from the three major outfalls in 1987, before any remedial actions were taken, was 442 kg (972 lb). During 1999, 5.4 kg (11.9 lb) of uranium

migrated off site, a 98.8% reduction from the 1987 mass. Table 11-1 shows the mass of uranium that migrated off site during the intervening years. Mass has fluctuated from year to year with precipitation levels, remedial actions, land disturbance, and foundation and contaminated soil removal. The masses during 1995 and 1996 were at similar levels of 38.2 kg (84 lb) and 37.4 kg (82 lb). Because contaminated soil removal was completed for major sections of the site during 1996, levels for 1997 were reduced even further. The slight increase for 1998 may be attributed to increased precipitation. The 1999 mass is a historical low, which is the expected result of extensive site remediation.

The total annual uranium discharged from all NPDES outfalls during 1987 through 1999 is shown in Figure 11-5. These values include uranium discharged at the three major outfalls discussed above, as well as at other minor storm water outfalls and in the water treatment plant effluents. As shown on the graph, total uranium migrating off site in surface water has steadily decreased since 1987 and is now approaching background.



TOTAL ANNUAL URANIUM DISCHARGED AT NPDES OUTFALLS

FIGURE 11-5

REPORT NO.:	DOE/OR/21548-845	EXHIBIT NO.:	A/PI/008/0700		
ORIGINATOR:	BD	DRAWN BY:	GLN	DATE:	7/18/00

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DOE ORDERS

232.1A, *Occurrence Reporting and Processing of Operations Information*
5400.1, *General Environmental Protection Program*
5400.3, *Hazardous and Mixed Waste Program*
5400.5, *Radiation Protection of the Public and the Environment*
5480.1B, *Environment, Safety and Health Program for Department of Energy Operations*

5480.4, *Environmental Protection, Safety, and Health Protection Standards*
414.1A, *Quality Assurance*

REGULATIONS

10 CFR 830.120, *Quality Assurance*
10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*
10 CFR 835, *Occupational Radiation Protection*
36 CFR Part 800.5, *Protection of Historic and Cultural Properties*
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*
40 CFR Part 141, *National Primary Drinking Water Regulations*
40 CFR 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*
40 CFR 761, *Polychlorinated Biphenyls, Manufacturing, Processing, Distribution in Commerce, and Use in Prohibitions*
40 CFR 761.125, *Requirements for PCB Spill Cleanup*
10 CSR 20-7.031, *Water Quality Standards*
10 CSR 25-7, *Hazardous Waste Management Commission - Rules Applicable to Owners/Operators of Hazardous Waste Facilities*
10 CSR 80-3, *Solid Waste Management – Sanitary Landfill*

PROCEDURES

ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*
ES&H 9.1.2, *Surface Water Management*

APPENDIX A
Unpublished Documents

TELECON

DATE AND TIME 11:50 a.m. 5/9/00

PERSON RECEIVING THE CALL Rick Kelley

CALLER

ADDRESS

PHONE NUMBER

CONCERN OR QUESTION Population data for St. Charles County, Cottleville, Weldon Spring, and Weldon Spring Heights for the years 1998 and 1999.

	Estimated population 1998	1999
St. Charles County	268,600	277,200
Cottleville	2,963	2,963
Weldon Spring	5,500	5,500
Weldon Spring Heights	85	85

HOW IT WAS ADDRESSED I called the St. Charles County Planning and Zoning Commission and the respective mayors for each city/town.

FOLLOW-UP NEEDED

SIGNED Rick Kelley

TELECON

DATE AND TIME 2:55 p.m. 3/28/00

PERSON RECEIVING THE CALL Rick Kelley

CALLER John Ronchetto

ADDRESS Mo. State Highway Dept. - Weldon Spring

PHONE NUMBER 314-441-8471

CONCERN OR QUESTION

'99 # of employees = 9

# of weeks worked = 52

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

TELECON

DATE AND TIME 11:50 A.m. 3/27/00

PERSON RECEIVING THE CALL Rick Kelley

CALLER Debbie Faber / Claudia

ADDRESS Francis Howell High School

PHONE NUMBER 636-926-8773

CONCERN OR QUESTION

# of employees = Approx. 120

# of students = 1,408

weeks in school = Approx 36 weeks

employees work 52 wks. / year

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

TELECON

DATE AND TIME 11:45 a.m. 3/27/00

PERSON RECEIVING THE CALL Rick Kelley

CALLER Denise Lehmann

ADDRESS Busch Wildlife Area

PHONE NUMBER 636-441-4554

CONCERN OR QUESTION

# of employees = 45

# of weeks worked = 52

# of visitors to site = Approx. 300,000 - 600,000

* people at residence = 3 (1 employee)

Residence is located across from new entrance

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

TELECON

DATE AND TIME 3/27/00 11:35 A.m.

PERSON RECEIVING THE CALL Rick Kelley

CALLER Master Sgt. Tom Hill

ADDRESS Weldon Spring Training Area - Dept. of Army

PHONE NUMBER 636-441-8681

CONCERN OR QUESTION

# of Army employees - 2

# of weeks worked - approximately 32

subcontractors unknown

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

TELECON

DATE AND TIME 10:47 A.m. 3/29/00

PERSON RECEIVING THE CALL Richi Kelley

CALLER Jan Talbelt

ADDRESS Francis Howell High School Annex - Personnel

PHONE NUMBER 636-441-0088

CONCERN OR QUESTION

'99 # of employees at annex = Approx 53

# of weeks worked = 52

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

TELECON

DATE AND TIME 11630 3/27/00

PERSON RECEIVING THE CALL Rick Kelley

CALLER Dan Kline

ADDRESS St. Charles Planning & Zoning

PHONE NUMBER 636-949-7335

CONCERN OR QUESTION

Average # of people per household from last census 2.82, but probably too low.

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

APPENDIX B
Assumptions and Scenarios for Dose Calculations

A. Dose from the Chemical Plant and Raffinate Pits to a Maximally Exposed Individual.

The following dose assessment is for a maximally exposed individual (MEI) employed full-time (2,000 hours per year) at the Missouri Highway and Transportation Department (MHTD) maintenance facility. The critical receptor station representing the MHTD facility includes AP-2001 (radioactive airborne particulate), RD-2004 (radon and thoron gas), and TD-2004 (direct exposure). While other perimeter locations measured airborne radioactive constituents during 1999 in concentrations greater than established background levels, the chosen scenario results in the maximum total effective dose equivalent (TEDE) to a member of the public. Additional dose scenarios are considered and discussed in Section D of this Appendix, Collective Population Effective Dose Equivalent (CPEDE).

1. Inhalation:

   a. Airborne Radioactive Particulates: Not applicable since the annual average concentration measured at AP-2001 was indistinguishable from background.

   b. Radon and Thoron Gas: Not applicable since the annual average concentrations of radon and thoron gas measured at RD-2004 were indistinguishable from background.

2. External Gamma Pathway: Statistical analysis of environmental TLD results indicated that the annual exposure at station TD-2004 was greater than background (see Section 4.2). This station measured an effective dose equivalent (EDE) of 67.6 mrem (0.68 mSv), based on an entire year (8,760 hours) of exposure. Subtracting the average background total exposure of 56.1 mrem (0.56 mSv), the net annual dose equivalent was 11.5 mrem (0.11 mSv). The EDE due to gamma exposure for a MEI at the MHTD facility is thus:

   EDE (external) = (gross TLD result – average background TLD result) x exposure time

   = (67.6 – 56.1) mrem/y x 2,000 hr x 1 y/8,760 hr

   = 2.63 mrem (0.026 mSv)

3. Ingestion Pathway: Because no bodies of water exist at the MHTD maintenance facility, fishing, swimming, and ingestion of contaminated water do not constitute realistic scenarios.

   The TEDE is therefore equal to the external EDE, or 2.63 mrem (0.026 mSv).

B. Dose from the Weldon Spring Quarry to a Maximally Exposed Individual

Because air monitoring results at the quarry did not exceed background levels in 1999, and ingestion pathways are implausible (access to the quarry area is restricted by a chain link fence), no dose assessment is necessary for an individual located near the quarry.

C. Dose from the Vicinity Properties to a Maximally Exposed Individual

Burgermeister Spring, located at the Busch Memorial Conservation Area, contains elevated concentrations of radium, thorium, and uranium. It is assumed that an individual walked past Burgermeister Spring once a week during 1999, stopping during each visit to drink one cup (0.237 l) of water from the spring. Since there are 52 weeks in a year, the individual ingests (52 x 0.237) liters of water, or 12.3 liters (3.24 gal). No radiological exposure is calculated for the individual for inhalation or external exposure because environmental monitoring results indicated radioactive air particulate, gamma exposure, and radon to be no greater than background levels at this location.

The maximum net concentrations recorded in 1999 for the radionuclides detected in Burgermeister Spring and their corresponding dose conversion factors (DCFs) for ingestion are:

RADIONUCLIDE	1999 MAXIMUM RECORDED CONCENTRATION (pCi/l)[a]	DOSE CONVERSION FACTOR FOR INGESTION (mrem/pCi)
Total Uranium (soluble)	82.1	2.69E-4 (Soluble)
Ra-226	0.93	1.33E-3
Ra-228	1.25	1.44E-3
Th-228	0.057	3.96E-4
Th-230	0.178	5.48E-4
Th-232	0.031	2.73E-3
Ra-224	0.057	3.66E-4
Pb-212	0.057	4.56E-5

(a) Ra-224 and Pb-212 concentrations derived from measured Th-228 concentration, based on assumption of secular equilibrium.

The above DCFs are obtained from EPA's *Federal Guidance Report No. 11* (Ref. 30).

The total effective dose equivalent (TEDE) is calculated by summing the doses contributed by each radionuclide present in the water, as shown below:

TEDE (ingestion of contaminated water) = TEDE (total uranium) + TEDE (Ra-226) + TEDE (Ra-228) + TEDE (Th-228) + TEDE (Th-230) + TEDE (Th-232) + TEDE (Ra-224) + TEDE (Pb-212)

where:

TEDE (ingestion of contaminated water for a given radionuclide) = Concentration (pCi/l) x Volume of Water Ingested (L) x Dose Conversion Factor (mrem/pCi)

TEDE (total uranium) = 82.1 pCi/l x 12.3 l x 2.69E-4 mrem/pCi

= 0.27 mrem

TEDE (Ra-226) = 0.93 pCi/l x 12.3 l x 1.33E-3 mrem/pCi

= 0.015 mrem

TEDE (Ra-228) = 1.25 pCi/l x 12.3 l x 1.44E-3 mrem/pCi

= 0.022 mrem

TEDE (Th-228) = 0.057 pCi/l x 12.3 l x 3.96E-4 mrem/pCi

= 0.0003 mrem

TEDE (Th-230) = 0.178 pCi/l x 12.3 l x 5.48E-4 mrem/pCi

= 0.0012 mrem

TEDE (Th-232) = 0.031 pCi/l x 12.3 l x 2.73E-3 mrem/pCi

= 0.001 mrem

TEDE (Ra-224) = 0.057 pCi/l x 12.3 l x 3.66E-3 mrem/pCi

= 0.0026 mrem

TEDE (Pb-212) = 0.057 pCi/l x 12.3 l x 4.56E-5 mrem/pCi

= 0.00003 mrem

Thus, the TEDE for all radionuclides combined is (0.27 + 0.015 + 0.022 + 0.0003 + 0.0012 + 0.001 + 0.0026 + 0.00003) mrem, or 0.31 mrem (3.1E-3 mSv).

D. Collective Population Effective Dose Equivalent (CPEDE)

Exposure points are locations near the WSSRAP where members of the public have the potential for exposure to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All four pathways are addressed for the CPEDE. Exposure to above-background radionuclide concentrations in food or water is applicable only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the site or from materials stored at the site. If there is no reason to suspect that environmental monitoring results are different from the appropriate background monitoring results, then the area surrounding the environmental monitoring station is not considered an exposure point. Therefore, neither the population near that station nor the population beyond the station would be included in the CPEDE.

A collective population dose assessment is performed at the exposure points where above background environmental monitoring results are obtained and a potential for public exposure is suspected. All five applicable pathways are addressed for this estimate.

1. Airborne Radioactive Particulates

In 1999, annual average airborne radionuclide concentrations (as measured by high volume monitors) at all critical receptor locations were indistinguishable from background. However, a statistical analysis of low volume monitoring results indicated that, at the 95% confidence level, eight chemical plant perimeter locations had ambient gross alpha concentrations greater than the 52-week background average. Two of these stations, AP-2005 and AP-2008 are in areas likely to be frequented by members of the public. Stations AP-2005 and AP-2008 are located near the WSSRAP office buildings and trailers, where approximately 160 employees work an assumed average of about 2,500 hours per year. Because the area is under DOE control, these individuals are not considered members of the public, but are treated as such for purposes of determining a collective population effective dose equivalent.

The annual gross alpha concentration at Stations AP-2005 and AP-2008 were 1.7 E-16 μCi/ml and 2.6 E-16 μCi/ml, respectively above the 52-week background average. The AP-2008 result is used in the calculation below for the CPEDE because it is

higher than the result measured at AP-2005. It is assumed that the gross alpha concentration at AP-2008 consists of the radionuclides common to the disposal cell.

The generic equation used to calculate CPEDE due to inhalation of radioactive airborne particulates is:

Collective Population Effective Dose Equivalent (inhalation of air particulates) = Net airborne particulate concentration (μCi/ml) x Appropriate Effective Derived Air Concentration (μCi/ml) x Exposure time (hours) x 2.5 mrem/DAC-hr x number of individuals

CPEDE (airborne particulates) = 2.6E-16 μCi/ml x 1 DAC/5.0E-12 μCi/ml x 2,500 hours x 2.5 mrem/DAC-hr x 160 persons x 1 E-3 rem/mrem

= 0.052 person-rem (5.20 E-4 person-Sv)

2. Radon/Thoron Gas Exposures

Statistical analysis of annual integrated radon (Rn-220 and Rn-222) alpha track monitoring results indicated that all critical receptor stations had concentrations that were indistinguishable from the annual average background concentration. In addition, the only elevated perimeter result occurred at Station RD-3003, located along the southwestern site perimeter, in an area that is not expected to be frequented on a regular basis by members of the public. Therefore, inhalation of radon and thoron gas is not included in the CPEDE estimate for 1999.

3. External Gamma Pathway

The two above-background gamma monitoring locations likely to be frequented by members of the public in 1999 were Station TD-2004, located near the MHTD facility, and Station TD-3003, located along the southwestern site perimeter. As mentioned in the previous section for Station RD-3003, TD-3003 is not in an area that is frequented by members of the public. Therefore, only the station TD-2004 result is considered in the CPEDE external gamma pathway calculation. The equation used to calculate collective population effective dose equivalent due to external exposure is:

CPEDE = Net measured exposure (mrem) x exposure time hr/8,760 hr x # persons x 1 rem/1,000 mrem.

CPEDE (TD-2004) = 11.5 mrem x 2,000 hr/8,760 hr x 9 persons x 1 rem/1,000 mrem

= 0.024 person-rem (2.4 E-4 person-Sv)

4. Ingestions of Food or Water

Exposure to above-background radionuclide concentrations in food or water by a significant human population is applicable only for visitors to the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are used for fishing and boating activities. In 1991 the Missouri Department of Conservation conducted a year-long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities (Ref. 31). Because this study is nearly 10 years old, and the population of St. Charles County has increased significantly during the past decade, the numbers in the study have been increased by 25% for purposes of this dose assessment.

Fishing at the Busch Conservation Area is assumed to have averaged 2.5 hours per visit for the approximately 200,000 visits to the area for that purpose (assuming a fish-caught to time-spent ratio of 0.4 fish/hour and a 0.50 ratio of fish kept to fish caught for a total of 100,000 fish). Assuming that each person keeps one fish, the population of concern would be 100,000 persons. For the water ingestion scenario, boating is the activity assumed to provide the potential for incidental water ingestion. An estimated 7,480 visits were made for the purpose of boating with an average of 5.7 hours per visit. Assuming that each visit constitutes one individual, the total population would be 7,480 persons. Each of these ingestion scenarios is further addressed in the calculations below.

a. Collective dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area is based on the following assumptions:

- Each person of the 100,000 population is assumed to consume one fish.

- The edible portion of a fish is assumed to have a mass of 200 g over a 1-year (365 days) period, the average consumption rate specific to the affected population is 200 g/365 days, or 0.55 g/person/day.

- Fish samples were last collected in 1998 as part of the WSSRAP biological monitoring program. Based on a total uranium concentration of 0.019 pCi/g obtained from a composite of sunfish samples collected in Lake 35 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population effective dose equivalent is:

Population Dose Equivalent (fish ingestion)

= consumption rate x total uranium concentration in fish x exposure time x total soluble uranium dose conversion factor x persons

= 0.55 g/day x 0.019 pCi/g x 365 day x 2.69 E-4 mrem/pCi x 100,000 persons x 1 rem/1,000 mrem

= 0.103 person-rem (1.03 E-3 person-Sv)

b. Collective dose estimate due to incidental ingestion of water at the Busch Conservation lakes is based on the following assumptions:

- Each person of the 7,480 population makes one boating visit on an annual basis, and 5% of the visit is spent swimming (0.285 hours/visit).

- Maximum total uranium surface water content is 10.7 pCi/l (obtained from Lake 35 in 1999), and ingestion rate is 0.05 l/hour (Ref. 31).

Population Dose Equivalent (water ingestion)

= ingestion rate x average total uranium concentration in Lake 35 water x exposure time x total soluble uranium dose conversion factor x number of individuals

= 0.05 l/hr x 10.7 pCi/l x 0.285 hr x 2.69E-4 mrem/pCi x 7,480 persons x 1 rem/1,000 mrem

= 0.0003 person-rem (3.0E-6 person-Sv)

Therefore, the CPEDE obtained from ingestion of food or water at the Busch Memorial Conservation Area is:

Dose (fish ingestion) + Dose (water ingestion)

= 0.103 + 0.0003 person-rem

= 0.103 person-rem (1.33E-3 person-Sv)

The 1999 total collective population effective dose equivalent (CPEDE) for all applicable pathways addressed in this section is:

CPEDE (airborne particulates) + CPEDE (gamma exposure) + CPEDE (ingested food and water)

= 0.052 + 0.024 + 0.103 person-rem

= 0.18 person-rem (0.0018 person-Sv)

E. Airborne Radioactive Release Estimates

During 1999, statistical analysis of annual average high volume monitoring results indicated no locations where airborne radionuclide concentrations were greater than background. However, eight low volume monitoring stations along the chemical plant perimeter indicated annual average concentrations that were statistically greater than the 52-week average background concentration. These stations were AP-2002, 2005, 2008, 2013, 2025, 3003, 3004, and 3014. The net annual average gross alpha concentrations at these stations were incorporated into a series of box models to estimate the total radioactive airborne particulate release from the site for 1999. Table B-1 summarizes the approximate activity ratios for the radionuclides contained in the waste common to each area of the site where an elevated annual average concentration was documented (see Section 4). The table also identifies the sources believed to be responsible for each station that indicated elevated readings for the year.

The box model approach provides conservative results and is used in place of Gaussian plume dispersion modeling, which is generally inappropriate for estimating ambient pollutant concentrations at receptors close to a source, which is the case for the perimeter monitors at the WSSRAP. Parameters required for inclusion in the box models include: net average gross alpha concentration (listed in Table B-1); the range of wind directions (measured out from the source) encompassing the area in which a given monitoring station is located, including the average wind speed and directional frequency (percentage of time that the wind blew toward those directions) for that range; the estimated release height at the fence line; and the box length, which is the distance between two points along the fence line drawn on either side of a monitoring station. (These two points are the midpoints between a given monitoring station and the next closest station along the site perimeter.) Table B-2 summarizes the parameters and assumptions used in the modeling.

The radioactive particulate release rate from the chemical plant is estimated by applying the following equation for each monitoring station result:

Release Rate (Ci/y) = Σ_i Σ_j[Box Length (m) x Release Height (m) x Wind Speed (m/s) x Net Annual Gross Alpha Concentration (Ci/m^3) x 3.1536 E7 sec/y x Directional Frequency]

where:

i = monitoring station
j = radionuclide

For example, for Station AP-2002, the total release rate is determined as follows:

Total Radioactive Airborne Particulate Release Rate (AP-2002) = 640 m x 3 m x 2.75 m/s x 4.90 E-16 Ci/m^3 x 3.1536 E7 sec/y x 0.380

= 3.10 E-5 Ci/y

The radionuclide-specific airborne particulate release rates based on annual results from Station AP-2002 are subsequently determined by multiplying the total AP-2002 release rate by each activity ratio listed in Table B-1 for the contributing source. Radionuclide-specific activity releases calculated for all monitoring stations are shown in Table B-3. The total activity release for each radionuclide released from the chemical plant area is found by summing the results in each column of the table.

Table B-1 Sources and Activity Ratios Corresponding to Elevated Gross Alpha Concentrations at Perimeter Low Volume Monitoring Stations

STATION ID	Net Concentration Above Background (Ci/m^3)	WSSRAP Source Contributing to Elevated Concentrations	Activity Ratios					
			U-234	U-235	U-238	Th-228	Th-230	Th-232
AP-2002	4.90E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-2005	1.70E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-2008	2.60E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-2013	4.80E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-2025	4.50E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-3003	4.00E-16	Disposal Cell	0.074	0.003	0.074	0.080	0.680	0.090
AP-3004	6.50E-16	TSA	0.074	0.003	0.074	0.080	0.680	0.090
AP-3014	3.90E-16	TSA	0.074	0.003	0.074	0.080	0.680	0.090

Table B-2 Parameters and Assumptions Used in Box Modeling to Determine Radioactive Airborne Particulate Release Rate from the WSSRAP for 1999

Box Model	Station ID	Range of Wind Directions (Wind Blowing From)	Average Wind Speed for Range (m/s)	Directional Frequency	Box Length (m)	Release Height (m)
1	AP-2002	123.75°-213.75° (SE, SSE, S, SSW)	2.75	0.380	640	3
2	AP-2005	303.75°-33.75° (NW, NNW, N, NNE)	3.27	0.249	412	3
3	AP-2008	258.75°-326.25° (W, WNW, NW)	4.03	0.162	206	3
4	AP-2013	236.25°-281.25° (WSW, W)	4.06	0.069	206	3
5	AP-2025	191.25° - 258.75° (SSW, SW, WSW)	2.87	0.197	252	3
6	AP-3003	78.75°-168.75° (E, ESE, SE, SSE)	2.26	0.225	503	3
7	AP-3004	11.25°-78.75° (NNE, NE, ENE)	2.71	0.146	412	3
8	AP-3014	56.25°-101.25° (ENE, E)	2.12	0.069	274	3

Table B-3 Radionuclide-Specific Activity Release Rates Corresponding to Monitoring Stations with Gross Alpha Results Greater Than Background for 1999

Station	Net Concentration	Release Rates (Ci/y)					
		U-234	U-235	U-238	Th-228	Th-230	Th-232
AP-2002	3.10E-5	2.29E-6	9.30E-8	2.29E-6	2.48E-6	2.11E-5	2.79E-6
AP-2005	5.40E-6	3.99E-7	1.62E-8	3.99E-7	4.32E-7	3.67E-6	4.86E-7
AP-2008	3.31E-6	2.45E-7	9.92E-9	2.45E-7	2.65E-7	2.25E-6	2.98E-7
AP-2013	2.62E-6	1.94E-7	7.86E-9	1.94E-7	2.10E-7	1.78E-6	2.36E-7
AP-2025	6.07E-6	4.49E-7	1.82E-8	4.49E-7	4.85E-7	4.12E-6	5.46E-7
AP-3003	9.68E-6	7.16E-7	2.90E-8	7.16E-7	7.74E-7	6.58E-6	8.71E-7
AP-3004	1.00E-5	7.42E-7	3.01E-8	7.42E-7	8.02E-7	6.82E-6	9.02E-7
AP3014	1.48E-6	1.09E-7	4.44E-9	1.09E-7	1.18E-7	1.01E-6	1.33E-7
Total Release Rates		5.15E-6	2.09E-7	5.15E-6	5.57E-6	4.73E-5	6.26E-6

F. Radon-220 and Radon-222 Release Estimates

All annual average Rn-222 and Rn-220 concentrations measured at critical receptor and perimeter locations were statistically indistinguishable from background levels. Therefore, it is assumed that no Rn-222 or Rn-220 gas above background levels was released from either the chemical plant or the quarry areas in 1999.

APPENDIX C
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